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A KEY TO THE HARMSWORTH SELF-EDUCATOR

At the heading of each article in the Self-Educator is the number of the group to which the article belongs, and a reference to this key indicates precisely the place of the article in the scheme of the book. This key, therefore, enables the student at any time to understand what has preceded and what is to follow any part of the work to which he may happen to turn.

Group 1.
Agriculture. Beekeeping. Gardening.
Farming. In all its Branches. Dairying. Poultry.
Beekeeping. A Practical and Commercial Course.
Gardening. How to Get the Most out of a Minimum of Land. Gardening for Pleasure and Profit. Market Gardening.

Group 2.
Art. Architecture. Glass. Earthenware. Carving.
Art. Theory and Training. Painting. Sculpture. Architecture (Theory. Styles. Practical Training). History and Ideals of Art.
Glass and Earthenware. Including Pottery.
Carving. Wood. Bone. Ivory. Horn. Tortoiseshell.

Group 3.
Biology. Psychology. Sociology. Logic. Philosophy. Religion.
Biology. Including Evolution, Palæontology, Heredity, Anthropology, Ethnology.
Psychology. Including Psychical Research.
Sociology. Including Political Economy.
Logic. The Science of Reasoning.
Philosophy. Systems of Thought.
Religion. History and Systems. Christianity.

Group 4.
Building. Cabinet Making. Upholstering. Fire.
Building. Excavating. Drainage. Manufacture of Bricks, Limes, and Cements. Bricklaying. Clay Wares. Reinforced Concrete. Masonry. Carpentry. Slates and Tiles. Plumbing. Joinery. Foundry and Smiths' Work. Painting. Paperhanging and Glazing, Heating, Lighting, and Ventilation. Building Regulations. Quantity Surveying. Building Abroad. In Business as a Builder.
Cabinet Making and Upholstering. A Practical Course.
Fire. Fireproof Materials. Fire Prevention. Fire Extinction.

Group 5.
Chemistry and Applied Chemistry.
Chemistry. Inorganic and Organic. Chemistry of the Stars.
Applied Chemistry. Acids and Alkalies. Oils (Fixed Oils and Fats; Waxes; Essential Oils and Perfumes; Paints and Polishes) Candles Soaps. Glycerin. Glues and Adhesives Starches. Inks Tar and Wood Distillation. Matches. Celluloid. Manure. Waste Products. Petroleum. Paper Making (including Paper Staining and Uses of Paper). Photography.

Group 6.
Civil Service. Army and Navy.
Civil Service. Municipal. National. Imperial.
Army and Navy. How to Enter Them.

Group 7.
Clerkship and the Professions.
Clerkship and Accountancy. Complete Training. Bookkeeping.
Banking. The Whole Practice of Banking.
Insurance. Life, Fire, Accident, Marine.
Auctioneering and Valuing. Practical Training.
Estate Agency. Departments and Officials of a Great Estate. Training a Land Agent.
Medicine. Training of a Doctor. Specialists. Veterinary Surgeons. Dentistry: The Dental Mechanic Home and Professional Nursing.
Church. How to Enter the Ministry of all Denominations.
Scholastic. Teachers. Professorships. Governesses. Coaches. Tutors.
Secretaries, etc. Institutions, Political Organisations. Lecturers.
Law. Solicitors and Barristers. Personal and Commercial Law. Copyright.

Group 8.
Drawing and Design.
Drawing. Freehand. Object. Geometrical. Brush. Memory. Light and Shade.
Technical Drawing. For Engineers; Coppersmiths, Tinmen, Boilermakers; Architects; Stonemasons; Carpenters and Joiners; Plumbers.
Design. Book Decoration. Illumination. Textiles. Wall Papers and Stencilling.

Group 9.
Dress.
Dress. Dressmaking. Underclothing. Children's Clothing. Tailoring. Millinery. Men's Hats. Furs and Furriers. Feathers. Shirts and Collars.

Group 10.
Electricity.
Electricity. Electrical Engineering. Telegraphs and Telephones (including operation of). Cables and Insulated Wire. In Business as an Electrical Engineer.

Group 11.
Civil Engineering.
Civil Engineering. Surveying. Varieties of Construction. Machines Employed. Roads. Bridges Railways and Tramways. Water Supply. Sewerage. Refuse. Hydraulics. Pumps. Harbours. Docks. Lighthouses. Foreign Work. In Business as a Civil Engineer.

Group 12.
Mechanical Engineering. Military Engineering. Arms & Ammunition.
Mechanical Engineering. Applied Mechanics. Workshop Practice. Tools (Hand and Miscellaneous. Machine Tools. Portable Machine Tools). Machines and Appliances (A General Guide to Construction). Clocks and Watches. Scientific Instruments.
Military Engineering. Pontoons. Bridges. Fortifications. Rafts. Trenches. Passing Rivers. Conditions in Peace and War.
Arms and Ammunition. Manufacture of Arms and Explosives.

Group 13.
Geography. Astronomy.
Geography. Physical. Political. Human. Commercial.
Astronomy. A Survey of the Solar System.

Group 14.
Geology. Mining. Metals and Minerals. Gas.
Geology. The Making of the Earth.
Mining. The Practice of Mining: Coal, Gold, Diamonds, Tin, etc.
Metals. Metallurgy. Iron and Steel. Iron and Steel Manufacture. Metal Work. Cutlery.
Minerals. Mineralogy. Properties of Minerals.
Gas. Manufacture of Gas.

Group 15.
History.
A Short History of the World from the Beginning.

Group 16.
Housekeeping and Food Supply.
Servants. Qualifications and Duties of Every Kind of Servant.
Cookery. A Practical Course, with Recipes.
Laundry Work. Washing. The Laundry as a Business.
Foods and Beverages. Milling. Bread-making Biscuits and Confectionery. Sugar Condiments. Fruit. Fisheries. Food Preservation Catering Brewing. Wines and Ciders. Mineral Waters. Tea. Coffee. Chocolate. Cocoa.

Group 17.
Ideas. Patents. Applied Education.
Ideas. The Power of Ideas in Life. Brains in Business.
Patents and Inventions. How to Protect an Idea.
Applied Education. Application of Education in Daily Life. Finance.

Group 18.
Languages.
How to Study a Language. Courses in Latin, English, French, German, Spanish, Italian, Esperanto, Greek. A Table of Root Words.

Group 19.
Literature. Journalism. Printing. Publishing Libraries.
Literature. A Survey of the World's Great Books and their Writers. Poetry Classics. Fiction. Miscellaneous How to Read and Write.
Journalism. A Guide to Newspaper Work, with Practical Training.
Printing. Composing by Hand and Machine. Type Cutting and Founding. Engraving and Blocks.
Books. Bookbinding and Publishing.
Libraries. Officials and Management of Libraries.

Group 20.
Materials and Structures. Leather. Wood Working.
Materials. The Characteristics and Strength of Materials.
Structures. The Stability of Structures.
Leather. Leather Industry. Leather Belts. Boots and Shoes. Saddlery and Harness Gloves. Sundry Leather Goods.
Wood Working. Design and Operation of Wood Working Machines. Wood Turning. Miscellaneous Woodwork.

Group 21.
Mathematics.
Mathematics. Arithmetic. Algebra. Geometry. Plane Trigonometry. Conic Sections.

Group 22.
Music. Singing. Amusement.
Music. Musical Theory Tonic Solfa Tuition in all Instruments. Orchestration. Conducting. Bell Ringing. Manufacture of Musical Instruments.
Singing. The Voice and Its Treatment.
Amusement. Drama and Stage, including Elocution. Business side of Amusement. Sports Officials.

Group 23.
Natural History. Applied Botany. Bacteriology. Natural Products.
Natural History. Botany. Kingdom of Nature—its Marvels, Mechanism, and Romance; Flowers, Plants Seeds, Trees, Ferns, Mosses, etc. Zoology; Animals, Birds, Fishes, Reptiles, Insects.
Applied Botany. Tobacco & Tobacco Pipes. Forestry. Rubber and Gutta Percha. Basket Making. Cork, Wattle. Cane Work. Barks. Brush Making.
Bacteriology. Pathological and Economic.
Natural Products. Sources. Values. Cultivation.

Group 24.
Physics. Power. Prime Movers.
Physics. A Complete Course in the Science of Matter and Motion.
Power. A General Survey of Power. Natural Sources. Liquid and Compressed Air.
Prime Movers. Engines. Steam. Gas. Heat. Turbines. Windmills.

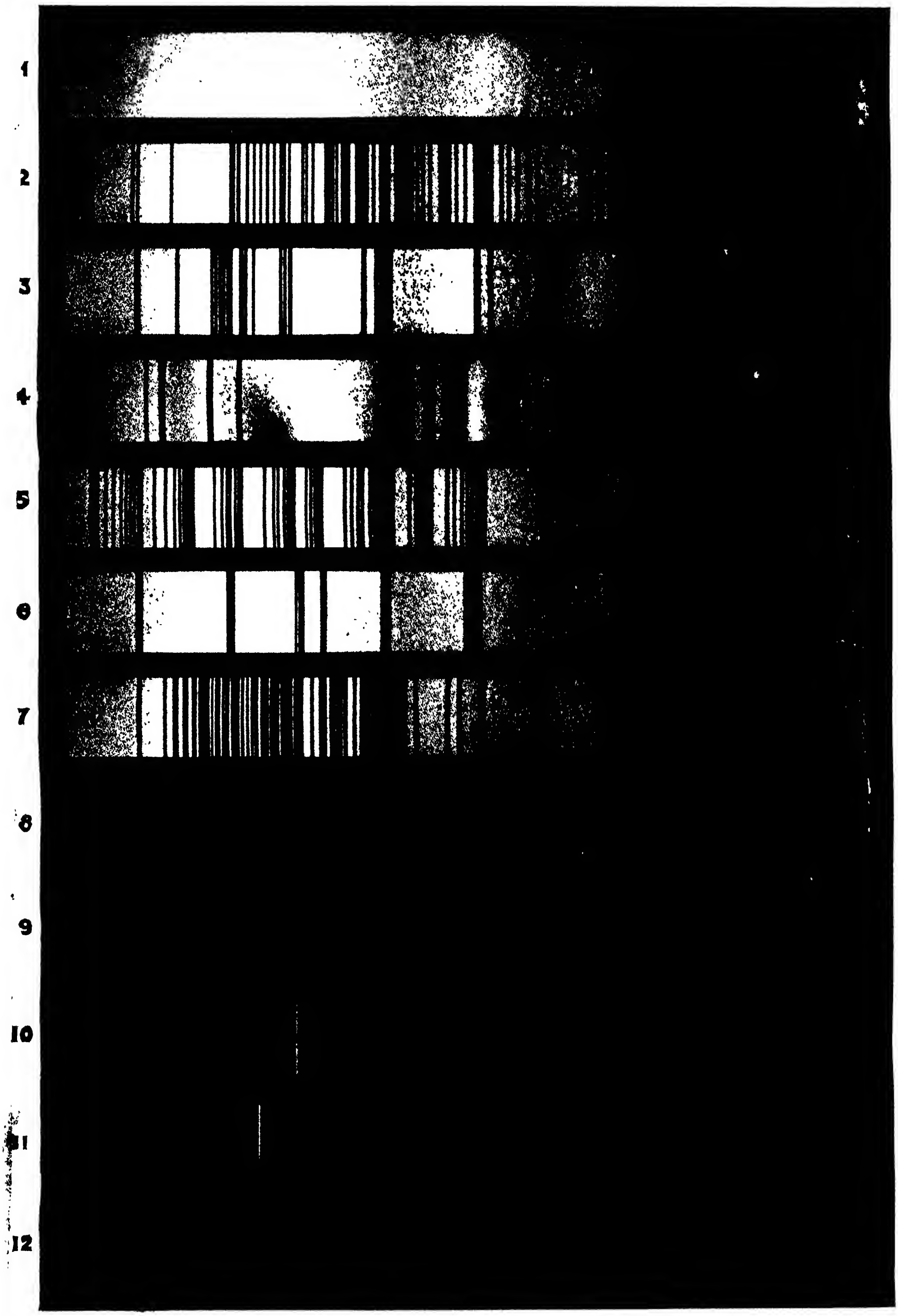
Group 25.
Physiology. Health. Ill-health.
Physiology. Plan of the Body. Digestive. Circulatory. Respiratory. Locomotor and Nervous Systems. The Senses.
Health. The Five Laws of Health Personal Hygiene. Environment. State Medicine and the Public Health.
Ill-health. General Ill-health. Its Special Forms. Common Ailments and Domestic Remedies.

Group 26.
Shopkeeping. Business Management. Publicity.
Shopkeeping. A Practical Guide to the Keeping of all Kinds of Shops.
Business Management. The Application of System in Business.
Publicity. Advertising from all Points of View As a Business.

Group 27.
Shorthand and Typewriting.
Shorthand. Taught by Pitmans.
Typewriting. Working and Management of all Machines.

Group 28.
Textiles and Dyeing.
Textiles. The Textile Trades from Beginning to End.
Dyeing. Dyes and Their Application.

Group 29.
Travel and Transit.
Travel. How to See the World. The Business Side of Travel.
Transit. A General Survey of Means of Communication.
Vehicles. Construction of Air, Land and Sea Vehicles. Business of Liveryman, Carrier, etc. Driving.
Railways. The Management and Control of Railways.
Ships. Shipbuilding. Shipping. Management of Ships.



THE STUDY OF THE STARS BY THEIR SPECTRA

1. Continuous spectrum 2. Solar spectrum 3. Spectrum of a red star 4. A temporary star 5. Alpha star in constellation Hercules 6. The star Sirius 7. The star Aldebaran 8. A nebula. 9. Calcium 10. Magnesium 11. Sodium 12. Hydrogen

[See Astronomy]

EVERY · DOOR · IS · BARR'D · WITH · GOLD · AND · OPENS · BUT · TO · GOLDEN · KEYS

HARMSWORTH SELF-EDUCATOR

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CONTENTS OF THIS VOLUME

THINKING SCIENTIFICALLY

How to Argue. A Man and His Conscience. Rationalism and Scepticism. Fallacies. Theory and Practice. The Laws of Thought. Herbert Spencer's Test of Truth

By Dr. C. W. SALEEBY

ONE reason why the synthetic philosophy of Herbert Spencer has created an epoch in the history of human thought is that it is the first system of philosophy in which the due balance between induction and deduction and the necessity for the correction of each by the other are fully recognised.

How Spencer "Squared" his System with Facts. In order to frame secure inductions, the author spared no pains. He spent three thousand hard-earned pounds and many years of labour in order to collect facts as to the social life of various peoples, ancient and modern, so that he might have a wide enough base upon which to build any sociological generalisations that might be forthcoming. When, on the other hand, he had reached an induction by this process, his next proceeding was to use it as the starting-point for a process of deduction, and then to see whether the inferences from it "squared" with facts. Thus, for instance, he has the inductions of ethics leading up to the principles of ethics, and the principles of ethics leading to practical maxims, which may or may not be already realised in human life.

And here is where faith comes in. You begin with a number of facts, and infer or induce from them an induction or generalisation; then you make a fresh start with this, saying to yourself: "Well, if this be so, what follows?" Deducing from this proposition according to the accepted laws of reasoning, you may well reach certain amazing conclusions.

A Man's Fight Against his Convictions. This was not so in the case we have quoted, but it has often been so. These conclusions are totally at variance with accepted belief. They seem incredible. They may involve the destruction of half one's convictions. Such cases are constantly encountered by the man who lives the intellectual life. What are the possibilities for him in such a fight?

One begins by re-examining the whole process. First of all, were the facts facts? Secondly, were there enough of them? Were they properly chosen? Or were they selected with a view to proving (not to proving *or disproving*) a certain proposition?—which is the commonest form of intellectual dishonesty, and a sin of which none can cry "Not guilty." But supposing that all these questions can be satisfactorily answered, then the induction must stand. It will be well at this point to ask ourselves whether we have not unconsciously made our generalisation rather too wide. The only conclusion from an adequate study of facts in this country and at this time may be that vaccination confers immunity from smallpox. But we may have neglected the qualifying clauses and may have declared that vaccination will protect every species of man or of animal from smallpox. This may or may not be true, but it is at any rate a fallacious or illogical induction from the facts at our disposal.

But suppose that our induction is free from all these flaws, then we must turn to our deductive reasoning, or ratiocination, and seek for fallacies in it. We shall do this the better if we have ever had occasion to make a systematic study of sources of fallacy. But suppose all fallacies have been excluded, there remain but two choices.

Faith and Doubt. Either we must have faith and accept the processes of our reasoning as valid, and Nature as a trustworthy and incorruptible witness, letting all our preconceptions go without a murmur, or we may be sceptical. In all ages there have been philosophers of both these classes. Those of the one class believe in the reason and the rational processes; they have faith. The proper philosophic name for their belief is *rationalism.* It is one of the unfortunate facts of language that words are constantly diverted from their proper meaning, and the word rationalism has suffered this fate. But, nevertheless, that is its proper meaning.

On the other hand, there are the philosophers who are sceptical. They declare that when the processes of logic are allowed rope enough, they always hang themselves. Therefore, whenever a conclusion is reached which seems absurd, such philosophers have no hesitation in saying that it *is* absurd, and that its absurdity demonstrates the worthlessness of the process by which it was reached. This attitude of mind is properly to be called *scepticism.* In the language of philosophic literature it is very commonly known as Pyrrhonism, from the Greek Pyrrho, the founder of the school of Sceptics.

"How Came it that Neptune was There?" The reader will not expect from us anything so impertinent as a dogmatic assertion that rationalism is the whole truth or that scepticism is the whole truth. On the contrary, we believe that it is the truth partially discovered by each that has kept it alive during thousands of years. Merely we note this—before leaving a fascinating subject—that the faith of the rationalist in the absolute validity of logic leads him into strange difficulties whenever his logic is pushed to the ultimate limits; whilst, as for the sceptic, who denies the validity of reasoning at all, he may be asked one question, typical of the question always put by science to sceptics, "How comes it that when Adams and Leverrier, each independently, placed his telescope upon a certain spot in the heavens, *Neptune was there?*"

We may also note that, just as absolute rationalism can always be made to look foolish, so absolutely consistent scepticism is impossible as a practical guide of life. The absurd stories invented about the sceptical philosophers, such as Pyrrho, are a testimony to the popular recognition of this truth. Let us note, also, that the reader should try to make up his mind about scepticism, provisionally, at any rate. For if his conclusion be that the rational or logical processes are untrustworthy—even proximately—plainly he must read, let us say, the course on Philosophy, just as one reads Mark Twain, by way of *divertissement*, and his only comment on concluding will run, "What fools these mortals be."

Therefore. Reading this course so far as it has gone, any student of logic prior to 1843, and many students since, might wonder when, if ever, the writer would proceed to discuss logic at all. It is now certainly time for us to consider, in outline, that rational process with which alone logic used to be supposed to be concerned—the process of "*pure reasoning*," "ratiocination," "deduction," "*a priori* argument," or "inference from the general to the particular." We may say that a study of deduction is a study of the conditions under which one may rightly employ the wonderful word "therefore." We call this a wonderful word because it is the mark of the rational process, which has been extolled as wonderful in all ages.

So-and-so is so-and-so; therefore, a new conclusion follows—really the new conclusion is implicit or bound in the old one. If the premise be granted, the conclusion is inevitable. One does not need to look, so to speak; one knows that it must be so, without looking, without experiment or observation, and one can thus reach sure conclusions which are in their very nature incapable of verification by experiment or observation.

Theory and Practice are Never Opposed. Thus, the power of this process is immeasurable; but, just in proportion to its power, it is dangerous—dangerous because, as Bacon shows, its facility and potency tempt the mind, leaving us to employ deduction which is insecure. Hence the repeated criticism that a thing is all very well in theory but does not work in practice. Long ago Mill showed that there is confused thought in such criticism. If a thing is really sound in theory, it will work in practice. There is no opposition between theory and practice, and the reason why practice repeatedly fails to confirm theory is that theory is unsound. Either the premisses of the logician are false or his reasoning from them contains a fallacy. Men say of a perpetual motion machine that it works admirably on paper, but that somehow the results are not obtained in practice. But such a machine does *not* work admirably on paper; it is only thought to do so. If it really did so it would work neither better nor worse in practice.

Deduction has one great instrument. Every deductive argument without exception can be cast into a form which illustrates the employment of this instrument. It was first recognised by Aristotle, and so searching and thorough was the founder of logic in his investigation of this great rational instrument that more than 2,000 subsequent years have added very little to his study of it. This instrument is known as the syllogism; and time was when the study of logic was the study of the syllogism. Nowadays we may employ such a term as the syllogistic logic synonymously with the deductive logic. Right deduction is the right use of the syllogism. It is not our hopeless purpose here to discuss in a column or two a subject about which books innumerable have been written. We can merely present the barest outlines of it to the reader.

The Syllogism, the Great Instrument of the Mind. What, then, is this marvellous *organon* or instrument by means of which the mind is enabled, by its own power alone, and without reference to the external world at all, to discover new facts? Let us begin with a concrete instance, such as has already been quoted. "All men are mortal: I am a man; therefore I am mortal." This argument, with its three propositions and three terms, is a syllogism. Every syllogism has three and only three terms—the major term, the minor term, and the middle term. Every syllogism contains three and only three propositions, which are called the major premise, the minor premise, and the conclusion, and the middle term must be "distributed" once at least in the propositions. In the instance which has been quoted, the three terms and the three propositions are evidenced. The middle term, the distribution of which is essential, may be recognised by the fact that it does not occur in the conclusion—the invariable rule. Obviously, it is the term "men." Furthermore, as in all syllogisms, the minor term is the subject of the conclusion, "I"; and the major term is the predicate of the conclusion, "Am mortal."

Furthermore, every syllogism, such as this, compares the major and the middle terms in a major premise—"All men are mortal"—and similarly compares the minor and middle terms in a minor premise—"I am a man"—whilst the third proposition or conclusion contains the minor and major terms alone—"I am mortal." Properly speaking, one should always place the major premise first, and then the minor premise. But whatever the order, the premise containing the major—that is to say, the bigger or wider term—is the major premise.

The Middle Term. The all-important term of the syllogism is its middle term, and it is absolutely essential, as we have already said, that the middle term be distributed, and properly distributed. Error in this respect is perhaps the most common cause of what is called fallacy. The commonest source of fallacy is what logicians call "the undistributed middle." In such cases the major and minor premise may both be absolutely true, but the conclusion ludicrously false. To quote an instance from the distinguished logician Jevons, "by the middle term being distributed once at least, we mean that the whole

of it must be referred to universally in one premise, if not both. The two propositions :

All Frenchmen are Europeans,
All Russians are Europeans,

do not distribute the middle term at all, because they are both affirmative propositions," the predicates of which are undistributed. If, following the method of Euler, we draw a circle and call everything within it Europeans and then within that two little circles, one labelled French and the other Russian, we see that there is no real middle term. So far as the propositions are concerned Russians might or might not be Frenchmen. "Again, the two propositions

All Frenchmen are Europeans,
All Parisians are Europeans,

do not enable us to infer that all Parisians are Frenchmen." So far as the premisses are concerned, the circle Parisians need not be placed within the circle Frenchmen, but may be placed anywhere within the big circle, Europeans. This argument gives us an instance, since, as a fact, all Parisians are included amongst Frenchmen, of a case where premisses and conclusions of a syllogism are all true and yet the syllogism is fallacious.

Fallacies. The word fallacy, so important to the logician and containing an idea of the utmost importance for every serious thinker, is constantly misused in common speech, and common writing too. By an unfortunate confusion of thought the word is applied to any statement or belief that is asserted to be untrue. "It was a fallacy to think that the sun went round the earth," people will say. But this is an utter misuse of the term. A fallacy is not an error of fact or an error of statement. The belief that the sun went round the earth was not a fallacy ; it was arrived at by a fallacy or a fallacious argument, which is a very different thing. Similarly, as has often happened, truths may be reached by fallacies. A fallacy is an error of logic, or an error of reasoning. It is an impropriety of method, not an impropriety of belief. Correct premisses correctly reasoned from must always lead to correct conclusions. Correct premisses incorrectly reasoned from will usually lead to incorrect conclusions. By sheer chance correct conclusions may be thus reached, but they are not correct because the argument says so. Incorrect premisses correctly reasoned from must necessarily lead to incorrect conclusions ; incorrect premisses incorrectly or fallaciously reasoned from may lead to either correct or incorrect conclusions—but the latter more commonly, of course.

Truth may Lie Behind a Fallacy. The history of thought is full of instances of all these possibilities. Let us, then, in future use the word error to mean one thing and fallacy to mean another, realising all the possibilities ; not, for instance, hastily condemning a conclusion because it has been fallaciously arrived at, and realising that many true conclusions have thus been stated and that a non-fallacious argument for their truth may yet be forthcoming. Someone declares, for instance, that he has proved that the earth goes round the sun. When his arguments are studied they are found to be fallacious. But one would be a fool, therefore, to scoff at his conclusions. Truth and error are opposites but not truth and fallacy. Fallacy is a matter of interpretation or logic alone.

We have already noted that the first thinker to study the syllogism practically exhausted the subject, and it is a noteworthy fact that the intelligent student can usually recognise for himself without previous study the sound and the unsound, the logical and the fallacious argument.

The Logical Sense. Here, again, is a parallelism between logic and grammar, which is the logic of language. Everyone knows how at school there are inherent differences between children in respect of parsing, analysis, and the like. One boy never learns any of these things. They are absolutely self-evident to him from the first. To another, who is without the language sense, the operations and conclusions of parsing are mysterious and arbitrary from the first, and always remain so. He cannot be taught any more than one can teach the blind to see. The case is the same with logic, and one is almost inclined to hazard the proposition that the same boys belong to corresponding classes in both cases. Some men think coherently and consecutively though they may have scarcely heard the name of logic. One may meet an intelligent blacksmith, and begin to talk about the Education Bill, let us say, and in a moment he will declare "that is a bad argument," and be right. On the other hand, there are people who may be of great use in the world, capable, energetic, and trustworthy, to whom apparently one sequence of propositions is as consequent or inconsequent as another, who will support the truest beliefs by the most fallacious arguments, and who are practically as incapable of acquiring the logical sense as other people of acquiring the language sense.

This is not, of course, to say that training can do nothing, nor is it to say that the systematic study of fallacies is not worth pursuit, but it is to assert that the great majority of readers to whom the subject presents any attraction at all will find, if they pursue the subject further, that the greater part, if not the whole of it, has a peculiar character of being self-evident. The natural comments will be "of course," "obviously," "certainly."

Symbolic Logic. In comparatively recent times much has been made of a new method of studying or stating logic. If we are to state the syllogism in its simplest and most abstract terms, its simplest form will run thus : A is B, C is A, therefore C is B. Here, instead of propositions, we use symbols. All the other forms of the syllogism can similarly be represented by the use of such symbols, as also can those fallacies which are classified as "logical" as distinguished from "material fallacies.". For instance :

All Y's are X's.
No Z's are Y's,
therefore No Z's are X's.

This is a fallacious syllogism, the major term X being improperly distributed. The common-

sense comment on it will run "No one said that *nothing but* Y's are X's, and therefore the mere statement that no Z's are Y's does not exclude the possibility that some or all Z's may be X's." For instance, all birds are vertebrates, no mammals are birds, but it does not therefore follow that no mammals are vertebrates. It does not matter what particular terms be employed; the letters which have been used as symbols will serve the purpose of the systematic logician. The parallelism is, of course, obviously that between algebra and arithmetic. What is then called the *symbolic logic*, which discusses the subject in symbolic or algebraic form, has been proved to be of great value, and has been carried to a very great degree of complexity. The mere recognition of its existence is of the utmost value even to the elementary student, just as the smallest acquaintance with algebra is of value to the student of arithmetic. It teaches the inevitable and necessary character of the logical processes, no matter what particular terms be employed, just as algebra teaches the necessary and inevitable nature of mathematical truths, no matter what particular numbers be under discussion.

Kinds of Fallacies. Having endeavoured to clear up the real meaning of the word fallacy, so that the reader will never be guilty of fallaciously accepting the erroneous opinion that fallacies and errors are identical, or that the detection of a fallacy in an argument implies a condemnation of its conclusion, we do not propose to discuss the kinds of fallacy in detail. We have neither space nor necessity. But a few kinds of fallacy may be noted, because they are so extremely common, and because the terms describing them are so frequently met with. There are, for instance, the kinds of fallacy included by Aristotle under the term Irrelevant Conclusion. This has various varieties, but they are all much easier to understand than the strictly logical fallacies, to which we will not here refer, such as the fallacy of an undistributed middle, instances of which have already been quoted.

It is an instance of the fallacy of irrelevant conclusions to prove one thing when you think you are proving another. There is thus the celebrated advice given to the barrister for the defendant in a law suit, whose brief was marked "No case: abuse the plaintiff's attorney." It might be proved up to the hilt that the plaintiff's attorney was a blackguard. But that is an irrelevant conclusion. It is not what one set out to prove The Latin phrase for this is the *argumentum ad hominem;* another Latin phrase, *argumentum ad populum,* indicates another form of irrelevant conclusion, the instrument of dishonest orators of all ages, who appeal to the prejudices and private passions of the people.

Begging the Question. This familiar fallacy also has a Latin name, *petitio principii.* It is also often called arguing in a circle. To beg the question is to assume what you are seeking to prove. You use the conclusion as one of your premisses. Instances of this are too familiar to need quotation. Often, as the great Bentham pointed out, one may beg the question by a mere word; such words he called "question-begging epithets." Thus Jevons says, "In like manner we beg the question when we oppose any change by saying it is un-English." Then, again, there is the extremely common fallacy, also recognised by Aristotle, which is most commonly known by the Latin phrase *non sequitur*—it does not follow. This is most commonly applied to arguments wherein the conclusion has no real connection with the premisses. Lastly, there is the fallacy, recognised by Aristotle and constantly employed by barristers, which consists of assuming the answers to certain questions whilst putting a still further question? For instance, "When did you leave off beating your wife?" or, better still, "Have you left off beating your wife?" Obviously, the unfortunate husband condemns himself equally whether he answers yes or no. This is called the *fallacy of many questions*, and, as Aristotle pointed out, "Only a single question admits of a single answer; only one predicate of one subject ought to be affirmed or denied in a single answer. Therefore, several questions put as one, should immediately be separated into their several parts."

The First Law of Thought. Lastly, we may consider what have been called the three primary laws of thought. They are of interest not only in themselves, but also because so soon as we examine any deductive argument to its utmost, we find that the truth of these laws of thought is assumed. If two men are not agreed as to their truth, they cannot argue with one another. There is no common ground whatever from which they may start. Similarly, we saw when discussing inductive logic that all its arguments depend upon the acceptance of the tremendous proposition that Nature is uniform and causation universal. The discussion of these laws of thought is also of deep interest, because it shows us the relations between logic and psychology, or, so to speak, the dependence of the rational processes upon the structure of the reason. Logic is thus, at bottom, a province of psychology, and the validity of all logical or rational conclusions must stand or fall in the last resort with the validity of mental processes. "What is truth?" said jesting Pilate. But that is too great a question to be considered here.

These are the names of the laws of thought: *The law of identity, the law of contradiction,* and *the law of excluded middle.* The first is simply "*whatever is, is.*" That may not seem worth saying, but we must not be too hasty.

The Second Law of Thought. The second law, which has been named the law of contradiction, is this: *Nothing can at one and the same time both be and not be.* Sir William Hamilton, the great Scottish philosopher, suggested that this should really be called the law of non-contradiction, and perhaps that phrase expresses it better. The law of identity we may here ignore and take for granted, but the law of contradiction or non-contradiction is absolutely fundamental and essential. It implies that in so far as anything is black, it cannot at the same time be white. Define shut and open, and a door cannot be at one and the same time both open

and shut. This, says Jevons, "seems to be the most simple and general truth which we can assert of all things." It is the very nature of existence that a thing cannot be otherwise than it is; and it may be safely said that all fallacy and error arise from unwittingly reasoning in a way inconsistent with this law. All statements or inferences which imply a combination of contradictory qualities must be taken as impossible and false, and the breaking of this law is the mark of their being false.

The Third Law of Thought. The third law of thought, or the law of excluded middle, is as familiar in practice as the others, *Everything must either be or not be.* If a line exists at all, it is either a straight line or not a straight line. That, indeed, is evident. But there are cases which look as if the law were untrue—cases of quantity, as, for instance, in the use of such relative terms as hard and soft. Logic does not assert that there may not be degrees of softness or hardness. It simply asserts that if a given meaning be allotted to the word hard, a given thing is either hard or not hard. It is upon these three laws of thought that the syllogism and all its possibilities, together with the whole of inductive reasoning, are based.

A Great Test of Truth. These three laws, and pre-eminently the second, help us in some measure towards realising our great need, the establishment of some criterion of truth. The denial of these laws is inconceivable. *They must be so*—or, at any rate, if we are to be cautious, *we are so made that they must be so to us.* If there are any truths of which we can be certain, these are such truths. There is a great argument of Herbert Spencer's upon this subject. Like many before him he asked whether there is any test of truth. As students of psychology we will be prepared to agree that at best our perception of truth is at the mercy of our perceiving minds. The nearest approach to a test of truth, says Spencer, therefore, must be found by way of the ultimate laws of thought. He says: "In the last resort we must accept as true a proposition of which the negation is inconceivable." Our highest certainty may or may not be an absolute certainty, but, at any rate, it is a certainty based upon the inconceivableness of its denial. Whether or not absolute or infallible, our ultimate criterion of a certainty is the inconceivableness of its negation.

What the Reason Must Reject. Thus stringently judged, it will at once be seen that our highest certainties are very few. The most positive generalisation of science, for instance, the so-called laws of Nature, such as the law of gravitation, are not even in the neighbourhood of the highest certainties. One is defying no mental necessity in denying or questioning the law of gravitation. Yet, though this principle will not enable us to regard, as having the highest certainty, any but the three primary laws of thought and the necessary deductions from them, it is nevertheless of the utmost negative value. Any proposition, for instance, that defies a law of thought—any proposition, that is to say, which is inconceivable or only the negation of which is conceivable—must be rejected by the reason. It may very well be accepted by something other than the reason. But that is no concern of ours here. Here we are discussing merely the laws of reasoning, and, so far as these are concerned, such propositions must be rejected. There is, for instance, a highly paradoxical German system of philosophy, invented by Hegel. It is based upon the proposition that being and not-being are the same—a proposition which, as one may readily imagine, enables him to prove to his own satisfaction anything that he cares to prove. If this proposition of his is to be accepted in the sense which it bears, one does not need to have read any of Hegel in order to reject him. One is entitled to feel that there is no time for the consideration of conclusions which are founded upon an absurdity. Observe here the utter distinction between laws of Nature, so-called, and laws of thought. It would be a grave abuse of language to call the denial of the law of gravitation an absurdity, but that is just the word which occurs to us to describe a denial of a law of thought.

The Duty of the Reason. If we must be true to our reason in all matters, then the importance of recognising the law of contradiction, as we practically do, cannot be overestimated. It was said of a famous man of science, Faraday, that his science and religion did not quarrel, because he kept them in different pockets. This was as good as to imply that if they were in the same pocket they would quarrel, but such a position cannot satisfy the logician or the philosopher. He wants all his beliefs to be true, and he cannot conceive incompatible beliefs to be both true. If his science and religion appear incompatible, he cannot be content with keeping them in different pockets. First of all, he must ask whether they are really incompatible, and, if so, he must find out which is true and renounce the other. In its place he may find a different form of religion or a different form of science which, properly considered, is found to be compatible with its fellow.

Truth and Truth can Never be Opposed. Thus, he may finally reach a position where he does not need to shut his eyes to the law of contradiction or fight against the necessities of his own mind. He will neither declare that religion is superstition, nor assert that the face of Nature is false to the soul of Nature, or, in other words, that science does not express the truth. He will the rather subscribe to these sublime words of Herbert Spencer:

"Religion, everywhere present as a warp running through the weft of human history, expresses some eternal fact; while Science is an organised body of truths, ever growing, and ever being purified from errors. And if both have bases in the reality of things, then between them there must be a fundamental harmony. It is impossible that there should be two orders of truth in absolute and everlasting opposition."

LOGIC *concluded; followed by* PHILOSOPHY

DRAWING FOR THE PRESS

The Seriousness of the Press Illustrator's Art. His Masters Among the Moderns. The Law of Page-decoration. Medium, Materials, and Means

By HALDANE MACFALL

THE illustrating of books, magazines, and papers has produced some of the finest art of the last fifty years; it has, besides, been the means of livelihood for many artists who must have failed to earn either a living or fame in the painting of easel pictures. But to-day the art of illustration is sinking under the rivalry of photography, and except for the best class work it is in the hands of the most wretched artists. Nevertheless, if the student have a marked individuality in his style, he will—in illustration as in all art—inevitably come to the front. Indeed, the last ten years have given us the work of some of our most remarkable men.

Limitations and Greatness of Press Illustration. In designing an illustration or decoration for the Press, the student must above all things remember that he is working for what is called the process block—that is to say, he must so use his tools that his drawing may suit the rough treatment required for a daily paper, if he be drawing for a newspaper, or he may allow himself a more elaborate style if drawing for a handsomely printed magazine.

In other words he must simplify his style to suit the conditions under which it must be printed. Phil May evolved a marvellously simple and powerful style in order to get the best results from the rude conditions under which he had to work. Randolph Caldecott is the supreme master of the simple use of line and colour-wash in combination for the purposes of illustration, but it should also be noted that his works come out equally well in half-tone process blocks when required, without colour. No student should be without Joseph Pennell's book, "Pen Drawing and Pen Draughtsmen," which is a mine of illustration and contains much sound advice to the illustrator.

It is well to be clear upon one most important factor in the art of illustration from the start; the illustrator must take his art as seriously as though he were the best of painters or sculptors. By no other means may he achieve distinction in, perhaps, the most far-reaching of all the pictorial arts. Many men have but used the art of illustration as a means of pot-boiling, but this is sheer artistic suicide. Some of the artistic genius of our day has reached its highest achievement in this province, and one has only to think of Steinlen, of Charles Keene, of Randolph Caldecott, of Aubrey Beardsley, of Howard Pyle, of Sime, or Edwin Abbey to grasp the great reach of the art of the illustrator.

Media and Tools. In speaking of the art of illustration it should be clearly understood that the vulgar use of the term "etching" as applied to pen-work is absolutely wrong. Etching is a method allied to engraving on a metal plate. The art of etching and engraving, which is dealt with in a separate article [page 6111], is quite apart from process work, and is not very successful in illustration. Illustration can be—and in the case of Howard Pyle, for instance is—done from paintings, but the more ordinary media are pen and ink, or crayons, or a painting-brush, using charcoal grey and Chinese white for the values.

The tools and materials, then, are of the simplest; their use is dependent on the end required. For the roughest work, line is absolutely necessary. And it has the great advantage over wash-work (or paint) that every stroke of the artist's tool comes out exactly in the reproduction from his work. In speaking of line, the pen-line may be generally understood, but it must be remembered that many men get their line with a brush used as a pen; on the other hand the crayon, though a point, makes so blurred an arrangement of lines, that it has to be reproduced by the more expensive method of half-tone process, just as a wash-drawing has.

The wash-drawing is, in these days of process, marvellously closely rendered when the paper has a smooth surface and the printing is not too rough—as, for instance, in magazines and weekly and other periodical picture papers.

Modern, not Old Masters. Let us first of all take the art of pen-drawing for illustration. A smooth white Bristol board, a pen, and a bottle of liquid Indian ink, are the only materials necessary. What a vast range of technique lies in the use of such simple materials the student may see by comparing pen-and-ink drawings by Charles Keene, Randolph Caldecott, Walter Crane, William Nicholson, Aubrey Beardsley, S. H. Sime, Edgar Wilson, Edwin A. Abbey, Phil May [12], and many of the modern Frenchmen, in whose works we may see that almost any emotional effect may be got, for the gamut of expression ranges from Nicholson's sombre, resonant deep blacks to the light, gay movements of Abbey's sunlit Italian romantic designs for Shakespeare's comedies.

The student of pen-drawing will get little help from the old masters, unless perhaps he try to use the pen as Holbein used a pencil, or as Rembrandt used the etching needle. His masters will be among the moderns. And the student has the advantage that he may procure at a very small price the works of some of the greatest men in his art. In Spain there is the work of Vierge and of Casanova and of Fortuny. All three of these men use a light gay technique that wonderfully represents the sunlit atmosphere of their land. In France we have such fine penmen as Willette,

Steinlen, Rivière, Gerbault, Grasset, Helleu (whose etchings are fine lessons for the penman in musical, swinging line), Caran d'Ache, and a score of others. In Germany we have Menzel, Dietz, Stuck, Max Klinger, Sattler, and Vogel. In Danish work Hans Tegner is particularly fine. In American magazines particularly the student will find rich education.

The superb work of E. A. Abbey, Howard Pyle, Dana Gibson, Blum, and Pennell, to mention only a few of the brilliant army of American illustrators, is in itself an education in black-and-white work. In English books, magazines, and picture-weeklies may be found the finest work in the world, which includes Leighton's illustrations to the Dalziel Bible, Charles Keene in "Punch," Sir John Gilbert and Birket Foster, Millais, Rossetti, Fred Walker, Boyd Houghton, and Pinwell; and Fred Barnard, Charles Green, Randolph Caldecott, William Small, Fred Sandys, Holl, Mahoney, Tenniel, Sambourne, Du Maurier amongst the older men; whilst the nineties were glorified by the work of Aubrey Beardsley, Sime, Edgar Wilson, Gordon Craig, Phil May, Raven-Hill [10], Hugh Thomson, Maurice Greiffenhagen, E. J. Sullivan, Anning Bell, the Beggarstaff Brothers (W. Nicholson and J. Pryde), Byam Shaw, F. H. Townsend [11], and Bernard Partridge [13].

10. SMALL REPRODUCTION OF PEN-DRAWING BY L. RAVEN-HILL

Extract fr n Mabel's Corr ondence: "We had a scratch game with the Black and ue Club yest rday, but had a wful job to get any men. Enid's brother and a friend his turned u at the last m ent; but they didn't do much except call 'Off-side' or Foul every other minute, and they were ll as nervous as cats:

Crayon and Wash. What can be done with the crayon, even under the rough and ready conditions of an ordinary French paper, may be seen in the master work of Steinlen. His work for the "Gil Blas Illustré" should be in the hands of every illustrator, and his influence has produced in America two or three of its greatest living women artists, particularly Elizabeth Shippen Green and Jessie Wilcox Smith. In France we have also the fine journalistic work of Paul Renouard, and the dainty technique of the caricaturist Léandre, and the romantic work of Balluriau. In wash-work, the student will find superb examples in the work of Edwin Abbey, Howard Pyle, S. H. Sime, W. Nicholson, J. Pryde, Raven-Hill, Gordon Craig, Vierge, Stuck, Steinlen, and Greiffenhagen, and from the productions in black-and-white of the pictures of such masters as Frank Brangwyn, Whistler, Manet, Turner, Sargent, and the masters of painting, more particularly Velasquez, and the Japanese.

11. SMALL REPRODUCTION OF PEN-DRAWING BY F. H. TOWNSEND

LADY (*calling on new vicar's young ife*): "Have you seen the library at the Hall? Sir George is quite a bibliophile, kn "

VICAR'S WIFE (*warmly*): "Oh, I'n glad to hear that! So y of these wealthy men have *no* religion!"

The supreme law of the decoration of the printed page is that the print cannot be too simple and pure and clear. The decoration should be so placed on the printed page as to enhance the beauty of the page without in the least detracting from the simplicity, purity, and clearness of the print.

Decoration of the Printed Page. One of the worst evils that ever fell upon the English printed page was the Morris type and decoration. No human being, surely, can read the pages of these expensive editions with the slightest sense of pleasure or profit. The illustrating of certain French books with little senseless drawings dotted all over the page, particularly in the margin and in and out of the text, is a particular abomination that has found favour far too readily in inferior English magazines and books. It is a nice question whether the decoration of a page should ever go down the side of it—it seems to destroy the interest of the print. At the top or bottom, placed clear of the print, it enhances the page. Edwin A. Abbey (sometimes in collaboration with A. Parsons) is particularly happy in his placing of both the illustration and the decoration on the printed page, as may be seen in his edition of Goldsmith's "She Stoops to Conquer," or of his many illustrated old songs. Hugh Thomson, again, is most happy in his

treatment of the page. And both these men teach a splendid lesson as regards the decoration of the covers of their books and of the title-pages. The decoration of a page should have as close a relation to the subject of that page as though it were an illustration of the subject.

Fitness in Design. Another point for the student to remember is that mere geometrical lines, or meaningless designs, have no particular virtue for decoration; and any subject, no matter how real, may be decoratively treated. Above all, the student should remember to utter his decorative work in the spirit of his own day, and not filch inappropriate technique and style from Dürer and the dead centuries. The aim of decoration is fitness of design to the subject.

In working for Press illustration, then, especially for pen-and-ink work, or "line," as it is called, the tools and materials are very few and very simple. For pen drawing, the student needs a smooth, white paper—white paper on a card is better—and it cannot be too white. A hard pencil, a pen, a bottle of liquid black ink, complete his needs, in addition, perhaps, to a sharp knife and a piece of indiarubber. White Bristol board is excellent stuff. On Bristol board the pen moves freely in all directions, when the student is sufficiently master of his pen. Any hot-pressed paper of good quality will also prove useful. Even good lineless thin writing paper will be found excellent for pen work, when a drawing beneath it is to be traced as one draws—only it requires neat handling to paste it to a cardboard afterwards.

When a line is too thick, or there is a blot, if a sharp knife will not cut it away, Chinese white will blot it out. Or if you wish to redraw the line, paste a piece of white paper over it, and draw over it. If you wish to get a tone, or flat wash of shade, anywhere, simply run it on the drawing with a blue pencil, and the process engraver will fill it in with a stipple tint by mechanical methods. Being blue, it does not interfere with the photographic facsimile of your drawing upon the zinc block.

12. SMALL REPRODUCTION OF A PEN-DRAWING BY PHIL MAY

Overheard at a country fair: "'Ere y'are! All the jolly fun! Lidies' tormentors, two a penny!"

As regards ink, ordinary writing inks should be avoided. The artist needs the blackest of inks if he would get the best results from the process-engravers. Newman's, or Winsor & Newton's liquid lampblack, and Higgins's American drawing ink, can be recommended. The ink should dry dead, without shine, should flow easily, and not fur the pen. *Encre de Chine Liquide* is also much used. Except Higgins's, most of the inks tend to drop to the bottom as sediment. This must be guarded against. Indian ink shines, and is a trouble to make.

In pencil drawing, outline in pencil and then work over all freely in ink, making every ink line tell. But remember that every pencil line must be rubbed out afterwards, and that the rubbing has a tendency to "lift" the ink that is over it. If you are making the drawing to be much reduced, remember that in the reduction the lines tend to blur, especially when they cross in several directions. Altogether, it is advisable to avoid cross-hatching as much as possible, and to get the gradations of shading by thinner or thicker lines at wider or narrower distances, but always drawn in one direction.

Wash drawing is really painting in monochrome, the drawing in transparent washes being akin to water-colour painting, and the drawing in body colour to oil-painting. The two methods should be kept strictly apart. The values of body-colour—that is, black or sepia mixed with white—are not always accurately rendered by the camera, especially under the rays of electric light; and if solid white or body-colour is introduced into transparent wash-drawings, the result will frequently be vastly different from the artist's intention.

Working Hints. The artist should, above all things, avoid hard, rigid, mechanical effects of line. There is a tendency to do this from nervousness in the earlier years of one's apprenticeship to one's art; but it should be avoided like the plague. An excellent short cut to copying the main forms of any design which is to be treated in freehand, and so translated into the artist's

own style, is to trace the main lines on a piece of tracing-paper. Then turn the tracing-paper over and re-trace it on the back. You now get a sort of negative or drawing in reverse. Fix this down to the paper or Bristol board on which the drawing is to be inked or painted by sticking down the four corners with pieces of stamp paper. Though you now see the drawing right side up, the back of it holds a transfer which can be rapidly passed on to the board by running over its lines with the edge of a paper-knife, rubbed fairly hard upon the design on the tracing-paper.

It is best, before inking in, to do a little rough sketching with the pen on a scrap of paper, so as to start upon the drawing free from nervousness. The student will find that he "goes at it" with a will, instead of uttering his first few passages in a state of "stage fright." But when the tracing is employed, or a rough pencil sketch made, the student should never allow it to cramp his drawing, employing it always as a ghost to keep him right in his forms and proportions rather than as a taskmaster.

13. REDUCED FROM A PEN-DRAWING BY BERNARD PARTRIDGE

HOTEL-KEEPER (*who has let his "Assembly Room" for a concert*): "Well, sir, I 'ope you found the arrangement of the 'all satisfactory last night?"
MR. BAWLINGTON: "Oh, yes; everything was all right. There was only one thing to object to. I found the acoustics of the building not quite —"
HOTEL-KEEPER: "No, sir; excuse me. *What you smelt was the stabl next door!*"

Another word of warning. Individuality of style is everything; therefore, whilst the student is recommended to take certain modern masters of black-and-white as his model rather than go through the numbing grind of the antique, or the paralysing effect of "art schooliness," he should take *several* masters as his model, not one alone. Try and see life for oneself. For a hundred artists who can copy others there is but one who can state a pictorial idea in terms of self.

Continued

14. REDUCED FROM A PEN-DRAWING BY C. E. BROCK

THE VICAR'S DAUGHTER: "Awfully cold, isn't it, Mrs. Muggles?"
MRS. MUGGLES: "Yes, my dear. But, bless ye, I'm *lovely* and warm!"

15. SMALL REPRODUCTION OF A PEN-DRAWING BY TOM BROWNE

MISS HOBBS (*who dislikes tobacco*): "I see you are at your idol again!"
SMOKER: "Yes; I'm burning it!"

[Our illustrations of pen-drawing are reproduced by permission of the proprietors of "Punch," Messrs. Bradbury & Agnew]

BRUSHES AND BRUSHMAKING

Fibres, Hairs, and Bristles Used in Brushmaking. Modes of Drawing Brushes. Painting and Painters' Brushes. Machine Brushmaking

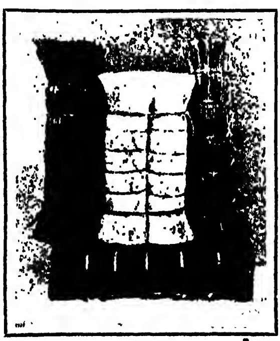
By J. C. VINCENT

THE all but infinite variety of brushes, each in its own way fulfilling the object of its being, performing a great variety of services, entitle this commodity to be called "legion." Brushes for the teeth, hands, hair, clothes, etc., are not luxuries, but necessities, and ourselves, our clothes, our houses, our cities, would not only be unsightly, but positively unhealthy, but for the friendly offices of the brush.

The materials used in brushmaking are as varied as brushes themselves. For the handles we use silver, pearl, tortoiseshell, ivory, horn, bone, various woods, and the quill or "stem part" of feathers, according to taste in some instances, in others to utility. For the brush, the important part, both animal and vegetable substances are used.

Fibres Used in Brushmaking. The least valuable are the vegetable products, known under the general term of fibre [1]. This includes *piassava*, known in the brush world as *bass*—a stiff chocolate-coloured weed which forms a kind of long, tangled undergrowth. The best of this comes from Bahia in Brazil. It is also exported from Para in the same country, while a less valuable quality is found in the forests of Central Africa. In its countries of origin, piassava is used for rope-making, but we shall recognise it best in the scavenger brooms of our borough councils and stables. The illustration [2] shows on the right the bass in length and in the rough state of importation; this is very often 6 ft. long. The three bundles on the left have been dressed, and cut to the lengths required for use.

Whisk is another important fibre. This has somewhat the appearance of straw, but is much stronger. It grows in Italy, the United States, and Canada. Two kinds of whisk are the Italian sorgho, or rice root, and the chiendent, or dandy whisk. The various kinds are used for making carpet brooms, furniture and clothes brushes, and the dandy brush for stable use.



1. FIBRE MIXTURES

Mexican fibres is the name given to those white and grey vegetable products which are used for making lime brushes, nail, bath, and other brushes used in water, and also for mixing with the hair and lowering the prices of baluster brushes and broomheads. This is the fibre of the Mexican aloe (*Agave rigida*).

Coconut fibre is also used in brushmaking, but only in very common brooms, clothes, carpet and a few other kinds of brushware. The illustration [1] of fibres shows the appearance after they have been dressed, and tied up with many strings in order to facilitate cutting to the required lengths with a block knife or guillotine.

Hairs for Brushes. Different brushes are made of different hairs, and the number of animals which lose their coats (to say nothing of their lives) in supplying these is very large. Among them are the horse, goat, bear, badger, beaver, mink, marten, sable, skunk, squirrel, kolinsky, and last, but most important, the hog.

Horsehair is used in making the lower-priced "all hair" brooms, scrubbing brushes, etc., and for adulterating the bristles of paint-brushes.

Badger hair is used principally in the manufacture of shaving-brushes. The best hair grows along the middle of the back, the least valuable on the underside and flanks. The Russian skins produce the shortest, and the German skins the longest hair. The value of badger hair lies not only in the length, but also in the colour. The value increases with the whiteness of the tip and the blackness of the rim of colour just below the tip. After the hair has been removed from the badger skins and the wool combed out, it is tied up in little tufts or knots and immersed in hot water to remove the grease and dirt. The knots are then tied up, each in a separate roll of paper, the whole resembling a boy's kite-tail. The hair is straightened in the subsequent process of drying in a hot room.

Artists' Brush Hairs. The other hairs (the most important of which are sable, kolinsky, and squirrel) are used for artists' brushes. The *sable* and *kolinsky* are indigenous to Siberia, and it is in the tails alone that brushmakers are interested. The finished brush in each case is known as sable, but brown sable is alone rightly so-called. Red sable is the hair of the Siberian pole-cat (kolinsky). Sable tails are imported by the "timbre," or bundle of forty tails. To cleanse, they are separated and placed in a bag of bran, with the mouth tied, and an operation performed similar to kneading dough. The same process is carried out in cleansing squirrel tails. The article known to the brushmaker as *camel hair* is the product, not of the camel's body, but of the squirrel's tail. The wool, fur, or hair of the camel is quite useless in brushmaking.

Brush Bristles. Many persons confound hair and bristles and regard the two terms as interchangeable. But while it is true that all bristle is hair, all hair is not bristle. Bristle is the hair of the pig, not the pork-producer of our farms, but his cousin, the "bristle producer," who lives a freer, and therefore more valuable, life in the forests of Germany and the wilds of Russia. The value of the bristle producer increases as his distance in relationship from the farmyard hog increases; the more northerly his habitation, the longer and thicker his coat. The bristles are marketed in Russia at St. Petersburg and in Germany at Leipzig. At the latter place bristles form the staple commodity during the earlier days of the great Easter Fair.

The bristles arrive in England in immense variety, and an important part of a brushmaker's business is to blend and sort and dress them to the required length, stiffness, and colour for the kind of brush to be made. The hairs are sorted

on a bench fitted with a series of "engines," or steel combs, the teeth of which are graded so as to separate from the handful the bristles of the various stiffnesses. The bundles of bristles, however, contain various lengths as well as various stiffnesses, and the sorting into lengths is known as "dragging."

Bristle Dressing. A handful of mixed bristles is stood up against a "size-stick," or measure, marked with inches and parts of inches. Then the bunch is held in the left hand, and, with the right finger and thumb, bristles above the indicated length are gently pulled from the handful.

These processes are called "beating down on the root" and "dragging," and are repeated until the residue is as solid or "even" as requisite. The handful, now only, perhaps, half the original size, is at the bottom of a series of lengths, graded in quarter inches—say, from 3 in. to 6 in. or even 7 in.

Washing the bristles is another very important process. Tubs with vent pegs in the bottoms (to enable the water to be run off readily) are lined with bristles, layer on layer; soap is then chipped into the tubs, and boiling water poured on. We now take a handful of bristles from the tub, and, after well soaping a flat stone about 18 in. square, rub, or "grind" the bristles on its surface [4]. This looks easy, but the easiness of washing bristles comes only by experience. Notice, in passing, the curve on the bristle. This is seen in the unwashed bundles and in the washed handfuls, but is most pronounced in the layers on the rack which are ready for the drying-room. This curve is known technically as "the bend," and it plays a most important part in the brushmaker's handicraft, especially in that section devoted to painting brushes.

2. BASS DRESSING

Bleaching Bristles. The bristle is now ready for bleaching, where this is necessary. It should be noted, however, that this only gives tone to and increases the whiteness of the bristle. It is impossible by bleaching to turn black or grey bristles white. The bleach in general use among brushmakers is the fumes of sulphur. To bleach bristle we lay it out on a rack, which slides into a groove in the bleach-house, the arrangement being a series of racks in this place which resembles somewhat the series of racks in which a printer keeps his founts of type. All ventilators of the bleach-house are closed, and an iron crucible is placed on the floor. A piece of iron, which has been made red hot, is placed in the crucible, and sticks of sulphur thrown in with it. The door (which, of course, fits tightly) is shut and the sulphur fumes do the rest.

Classes of Brushware. Brushmaking is divisible into four classes—drawn work, set work, painters' brushes, and machine work.

In the drawn work class are grouped scrubbing, nail, cloth, hair and tooth brushes. We may take the tooth-brush as a good representative of the class. The bones are first "cropped"—that is, have the large ends sawn off, and slit lengthwise into several pieces. Each of these is then "profiled," or cut roughly to the shape for which each piece of bone is best adapted. Next they are "fashioned" to the perfect shape, and holes are bored in the head to take the bristle. The boring of tooth-brushes differs from most other kinds in that the holes are not bored quite through the stock or handle. They are then turned over and cut, or "graved," at the back with a fine circular saw in three, four, or five lines according to the number of rows of holes in the face.

The common mode of drawing brushes is shown in the illustration [8], although this is by foot power as well as by hand power. The stock is held in a vice, and a loop of wire or other material is pushed through from the back. Now we take a pinch of bristle, half the size of the hole to be filled, pass it half way through the loop, and, while holding it in position with the left hand, pull the wire with the right. The effect is to force it into the hole by bending the bristle in half, and the first knot will be completed. Now we double the wire again and the loop is formed in readiness to repeat the operation, until all the holes are filled.

The tooth-brush has now to be filled in at the back with white, blue, or red wax, the latter being the most generally used. The finishing of wood brushes, such as those for the hair and clothes, is necessarily different. When we have filled the stock, the brush is open at the back, revealing quite a maze of wire. We must well glue this side of the board, and place upon it the back of rosewood, satinwood, etc. These are then clamped tightly together with wooden screws and put by until the glue has quite set. It will then be possible with spokeshave, bow-saw, and glasspaper, to complete the shape and finish the brush [7]. Finally, the back of the brush is polished.

Trepanning Brushes. Another mode of brush drawing is known as *trepanning*. For this purpose the boards are bored in a similar manner to the tooth-brush stocks, but instead of graving the backs with a circular saw they are "long-holed." In this case, the holes comprising each row are connected inside the back by a hole bored through from the front of the head. A double thread is now passed down the "long-hole" on a needle or bodkin, and pulled out of the end hole of a series, or row, on the face of the stock. The loop thus formed is now ready for the reception of the tuft of bristle, which is drawn into the hole by pulling the ends of the thread.

This operation is repeated till all the holes in each row are filled. The long-hole is now pegged up, preferably with a sharp point of ivory, and the brush is ready for finishing and polishing. The system of trepanning brushes is very largely used in France, but the practice has grown very considerably in England during the last few years, and the firm of G. B. Kent & Sons—to whom we are indebted for the illustrations used in this article—have found it necessary during the past year to increase very considerably the number of employes engaged in this department of brush drawing.

3. BROOM-MAKING

Pan work derives its name from the "pan" round which the makers of this class of brushware sit. It is filled with pitch, kept fluid by the heat of a gas-ring beneath it. The illustration [3] shows the process observed. The stock, or wood part of the brush, is bored with holes of the required size and number. These, however, are not bored right through, but sufficiently deep to take enough material to make the brush effective and the knots secure. Again, all the holes are not bored upright. In boring some of the holes, the stock is held so that the drills enter at a slight angle, in order to effect the "spread" of the bristle, so much desired in the finished article. Notice the ball of whiting on the bench. This is rubbed on the hands to prevent the pitch from sticking to them.

4. WASHING BRISTLES

We now take the material of which the broom is to be made, and select enough to fill a hole; dip it into the pan (the root end, of course), and after scraping off the superfluous pitch, bind it round tightly with a piece of hemp or yarn Again dip into the pan, and, with a turn of the wrist, push the knot into the hole and the thing is done. The man on the left has the knot ready for the hole; the next man is binding a thread round the dipped roots of the knot, while the other workmen are setting the knots in the stocks of a broom and a baluster respectively. It is obvious that the ability to select just the right amount of material to fill the hole is the mark of the accomplished pan-hand. If too much be selected, waste ensues; while the broom is insecure if an insufficient amount be taken.

The most effective hair broom is made of pure bristles; it not only sweeps cleaner, but entails less labour, and for durability will outlast two of inferior quality. The best stable or scavenger broom is made of pure Bahia piassava, with which there is a pliancy and spring far surpassing that of African bass, though a very good broom can be made with 50 per cent. each of Bahia and of African bass.

Painting Brushes. These fall into two main divisions—those for artists and those for painters and decorators. Artists' brushes comprise those of camel hair and sable, and also many made with bristle. Painting brushes comprise such well-known varieties as sash tools, ground brushes, and stock brushes, either one knot, or compound. There are, of course, many other varieties, but they are, in general, only modifications of these.

In making the pencils for artists, we must use quills of various feathers. The sizes are known neither in numerical nor alphabetical sequence, but by name, from the smallest to the largest—lark, crow, duck, goose, swan, and for special purposes, even eagle and pelican. The quill cannot be manipulated in its native state, but by boiling it becomes soft, and the ends can be cut off without splitting the quill. We now remove the "pith" from the inside and place the cleaned quills in a basin of cold water, which keeps them quite soft and pliable, ready for use.

Artists' Pencils. A small bunch of hair from the tail of the sable, marten, kolinsky, or squirrel, is taken hold of at the point, or end opposite to the root, and by passing a comb (a metal one for preference) through it, the "flue," or wool, which surrounds the roots and grows close to the skin of the animals, is removed.

This hair cannot be handled as bristles are, because it is too fine. To get it quite even, it is divided into small bundles, and each bunch encircled with a cardboard tube. When we have about a hundred of these tubes—all standing on end with the roots uppermost—we take a piece of leather, about 5 in. wide, and long enough to encircle the whole, and strap it round them fairly tightly. The technical name for this is the "beater." If we now lift the beater the bottom will present the appearance of a round honeycomb, with cells rather large and circular in shape.

Great care must be exercised here, or the whole will shoot out, and much labour and time will be expended in gathering up the contents and getting them straight again. We now gently lift the beater about ½ in. from the bench, and just as gently drop it down again, holding it with both hands all the time. Repeat this operation smoothly and quickly, making a continual tapping noise, and, sooner or later, all the hair will have become quite "solid," or even, and ready for use.

We now take a "pinch" of hair—regulating the quantity according to the quill to be used—and tie the root tightly with hemp, covering this with coloured silk; wet the flag to keep it together and

5. MAKING PAINT-BRUSHES

bring it to a point, and insert it into the quill at the large end. A piece of wire of suitable thickness, known as a "driver," is now used to push the knot to the other end of the quill. The whole is put to dry, and the brush is made, the drying, and, therefore, hardening of the quill, affording an extra security to the knot.

Sable and Hog Hair Brushes. The best hair for artists' pencils is that of the kolinsky, known as "red" sable and "brown" sable, or sable proper. Sable is becoming so scarce and valuable, and therefore so expensive, that various martens and the mink have taken its place with many brushmakers. Sable hair is worth more per ounce than camel hair is per pound; moreover the former works to a much finer point, and has much more spring and durability.

Hog-hair artists' brushes, to be effective, must possess a good "dome," and the learner must remember that this must be produced without the aid of scissors, for if we trim the brush to a dome with these, we destroy the flag or split end of the bristle, and render the brush unsuitable and ineffective so far as "fine" or artists' work is concerned. A tool called a "canon" is used here. Its shape resembles a large thimble, with the sides straight, instead of converging; the head is shaped to the required dome and the tuft of bristle is placed in this, flag downwards. Now, while the left hand keeps the bristle in position, with the right we give the canon a succession of even taps on the bench, the result being that, when the tuft is removed, it has taken on the shape of the canon.

7. FINISHING HAIR-BRUSHES

Making Painters' Brushes. In dealing with the washing of bristles, attention was called to the "bend." It is most important for the painting-brush maker to keep the bend of the bristle one way, so that as the bunch is on the bench, it presents the appearance of a concave line [see the bristle on the drying rack—4]. The *sine quâ non* in making a paint-brush knot is to tie it together so that the bend of all the bristles faces inwards, and the flags, while not interlocking, form concentric rings.

The sash tool is a good representative of the single-knot paint-brushes. It is generally made on a "forked" or pronged handle, though sometimes the

8. DRAWING MACHINE

6. FINISHING SCRUBBING BRUSHES

handle is bored at the end, making a socket in which to insert the bristles. The knot is dipped in cement (generally made of resin and linseed oil). It is then placed between the forks of the handle and bound tightly round with string. The knots which are to be cemented are kept on a hot-plate to facilitate the penetration of the cement.

Another system of paint-brush making is known as tied work. The workman to the right in the illustration [5] is seen making a compound stock brush. The knot in this instance is divided in the middle, so as to fit on to the handle. It is then tied with copper wire to keep it in position. Though the majority of stock brushes have two knots only, there is quite a large number made with three and four knots, and some even with five.

The driven brush is another form. The knot in this case is pulled into a socket or binding. Sometimes this is a plain band of metal, at others it is made of copper or iron wire, or, again, of string. These bindings are made taper, or smaller at the top than they are at the bottom. After the cemented knot has been pulled into the binding, the handle is pushed through the centre of the brush and driven home with the pointed head of a hammer made for the purpose. The workman on the left of the illustration [5] is seen driving the handle home, the block at which he is working having a series of holes, varying in size, to admit the handle, and at the same time to give a solid bed on which the head of the brush can rest while the handle is driven home.

Grinding and Pointing. After the brushes have been made, certain of them—known as ground brushes—are ground on a stone in a way similar to that described in connection with washing the bristles. Before the brushes are taken to the drying-room they are pointed—that is, a piece of hemp is bound round the bristles in such a way as to keep them in shape. This is put on rather loosely, and great care must be exercised, in order that the brush shall dry in a presentable condition. It is very easy when pointing a brush to completely alter the set of the bristles, and therefore to render it less effective than it should be. An exception to the general rule of "turning in" the bend of painters' brushes occurs in making the painters' duster. In this, the flag of the bristle is made to turn to the circumference of the brush.

Testing Adulterated Brushes. In the manufacture of painting brushes, the brush made with pure bristles only, although the most expensive in initial outlay, is cheapest in the end. The pure bristle brush enables the workman to put the paint on evenly and effectively, while for wear and tear it will outlast several made from a mixture of bristle and horsehair. It is often difficult for a journeyman brushmaker to decide whether a painting brush is adulterated with horsehair, and therefore to the tyro it is well nigh impossible, except in those cases where adulteration is flagrant. One test is the existence of the flag (split end) in bristles, and its non-existence in horsehair. Another test is the greater flexibility and spring in bristle than in hair, and a further difference is that bristle tapers from root to flag, while horsehair is uniform in size all the way up. But the infallible, and therefore the best, test of all is to take a magnifying glass, when it will be observed that while the horsehair is cylindrical in section, the bristle is elliptical.

9. BONING AND FILLING MACHINE FOR TOOTH-BRUSHES

There are two tests to distinguish fibre from hair. One is to bend a piece of each, when the fibre, lacking the elasticity of hair or bristle, will have a tendency to crack, while the animal product will assume its previous position, none the worse for the operation. The other test is to set fire to a piece of each, when the fibre will burn quite readily, while the bristle will only splutter and curl.

The Care of Painters' Brushes. As these are so valuable, it behoves us to be careful in the manner of keeping them when not in use. A varnish brush must, on no account, be soaked in water, because this will destroy the cement used in manufacture, and thus render the brush unsound. For the same reason, a paint-brush should never be soaked in turpentine. A varnish brush may be kept in oil when not in use, and a paint-brush, after having been cleansed in turpentine, may be kept in water. On no account should a brush be allowed to rest on the bottom of a paint kettle. If brushes are allowed to rest on their bristles, the latter become twisted and quite unfit for effective work. A brush should be suspended from a hook on the side of the kettle. Sometimes a brush is put on one side uncleaned, and consequently it becomes quite hard. It can be rendered usable again by soaking it in linseed oil, but prevention is better than cure. New paint or distemper brushes should always be soaked in water before they are put into use.

10. FILLING NAIL-BRUSH BOARDS WITH FIBRE

Brushmaking by Machinery. The simplest of the machine-made brushes are flue and bottle brushes. They are made by taking a double length of wire and inserting the ends in a vice. The doubled end or loop is now put on a hook, fitted with a handle. We now take the weight of bristle allowed, and distribute it as a thin and even layer between the double wire at the end nearest the vice. Turn the handle, which, twisting the wire together, will give the spiral form distinctive of this class of brushware. There are, however, machines very much more complicated than this, and while we cannot go into the intricate mechanical questions involved, we would draw attention to one illustrated [10]. This shows the operator filling nail-brush boards with fibre by a principle known as "punching." The modus operandi is to drive a knot into the hole, and at the same time to "anchor" it into position with a metal clip arrangement. One may best liken it to a double-pointed staple. The punching not only forces it into the board, but opens the clip inside the brush, and thus secures the knot in position. In the hand-drawn brush the knots in each row are drawn (and therefore connected together) on a continuous wire; in the machine-punched brush each knot is isolated, and therefore self-contained. Dandy brushes for stable use are very frequently made on the "punched" principle, and so, too, are many forms of scrubbing brushes.

Bevelling and finishing scrubbing brushes by machinery has to-day been reduced to a fine art, and at the Hertfordshire factories of G. B. Kent & Sons gresses of these brushes are finished in the time that would be taken to finish dozens by hand labour. When we say finished, we do not mean made to shape only, but produced as eminently marketable commodities [6]. Another engineering triumph may be seen at the same factories. This is so remarkable that if it were possible for a mediæval brushmaker to visit again "the plane of his former triumphs," he would not only say that the machine was living and functional, but that it was endowed with reason. A bone handle is placed on the carrier, and the holes are bored evenly and regularly. Just the right quantity of bristle is picked out and wired to the stock, and the brush is made in a few seconds [9].

APPLIED BOTANY *concluded; followed by* TAXIDERMY

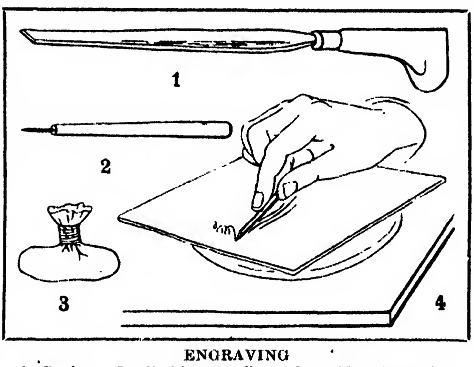
ACID AND LINE ENGRAVING

Copper-plate Etching and Dry-Point. Etching in Tones. The Old and Beautiful Art of Line Engraving and its Masters. Prints in Colour

By EDWARD F. STRANGE

AN etching is a print taken by the method known as "copper-plate printing" direct from a metal plate on which lines have been bitten by an acid or other mordant. The plate may be of any metal; but iron, steel, zinc or copper have generally been used by artists; and the latter so greatly exceeds the others in suitability that it is almost invariably chosen. Zinc, however, has certain qualities of its own, producing a strong, rich line which is excellent for broad effects. Its treatment in no way differs from that required by copper, and the description of the process which follows applies to both metals.

Preparing the Plate. The plate used should be of good and even quality and its upper surface given a fine polish—circular. Such plates can be purchased ready for use. The polished surface must be overlaid with a ground, composed, as a rule, of beeswax, asphaltum, Burgundy pitch, and gum-mastic in varying proportions; but equal parts of each may be taken as a good formula for general use. The ground may be applied: (1) hot, by means of a dabber; (2) cold, as a paste dissolved in oil of lavender, by means of a roller; (3) as a solution in chloroform poured over the plate. The dabber [3] is made of horsehair, enclosed in cotton-wool, with an outside covering of silk or kid; and it is advisable to keep the stock of ground in a silk wrapper to prevent grit from getting into it. The grounded plate should next be smoked to a perfectly even blackness, by being clamped in a hand vice and moved to and fro over the flame of a bundle of wax tapers.



ENGRAVING
1. Burin 2. Etching needle 3. Dabber for laying etching ground 4. Engraving on metal

The subject of an etching is drawn in line alone, the tool used being of steel, and called a needle [2]. This usually has a fine point and need not be otherwise, for though some etchers have employed a blunt tool for making broad lines, a better result is obtained by relying on the action of the acid for this purpose. The drawing may be made direct on the ground, in fine lines of uniform thickness, with pressure just sufficient to penetrate the ground but not to cut the copper; or, if desired, it may be transferred, either from a lead-pencil sketch made on thin paper, damped, laid upon the ground, and then passed through the press with a little less than ordinary printing pressure; or, again, it may be scratched upon gelatine with a needle, red chalk or some other pigment rubbed into the lines, and the transfer made in the press, as above, or by rubbing the back of the gelatine with a burnisher. In this case the gelatine should not be damped. When the drawing is finished, the back of the plate must be varnished with Brunswick black, to protect it against the action of the acid.

The Etching Bath. The drawing having been thus put upon the plate, the next step is that of subjecting it to the action of an acid bath which performs the function of etching—or eating out in the copper—the lines drawn with the needle. It need scarcely be pointed out that on the success of this delicate operation depends the whole merit of the final result, no matter how good may have been the original design. The bath is of porcelain, sufficiently large to enable the plate to lie conveniently within it, and shallow enough for the upper surface of the copper to be easily accessible. Various liquids—mordants—are used for biting-in at the discretion of the artist, who may, however, be advised to confine his attention at first to one only of the following, in order that he may become thoroughly well acquainted with its qualities and arrange the successive stages of the operation with certainty.

(1) *Nitric Bath.* Nitric acid, of specific gravity 1·42, and water in proportions varying from equal parts of each to $\frac{1}{3}$ of acid and $\frac{2}{3}$ of water, for copper. For zinc or steel much less acid should be used. Nitrous may be substituted for nitric acid.

(2) *Dutch Bath.* Hydrochloric acid, 10 parts; chlorate of potash, 2 parts; water, 88 parts.

(3) *Perchloride of Iron Bath.* A 40° Beaumé solution of perchloride of iron in water.

The plate is now immersed in the bath, and in the course of a few minutes the bright lines of the drawing will be seen to cloud over with minute bubbles of gas, produced by the action of the acid upon the metal. If the plate be removed from the bath, and the ground cleaned away with turpentine, it will be seen that every line drawn with the needle has been faintly eaten into the plate. If a proof be taken at this stage, the whole drawing will appear in fine lines such as are required for the lightest portion only of the print. Those portions which are destined to remain in this state must be covered again with ground. Stopping out, as this is called, is effected by a careful use of the dabber, leaving exposed all those parts which require strengthening. The plate is immersed again in the acid, and the whole operation repeated as often as necessary, until the proof shows a gradation, as nearly as possible perfect, from lines almost as fine as the needle-point itself to the deep

blackness which gives an etching its peculiar richness of effect. In the course of this proceeding it may be found, that the whole design is too light.

Re-biting and Retouching. To darken the design "re-biting" is necessary. The dabber cannot conveniently be used, as it is difficult with it to keep the ground out of the already bitten lines. The difficulty is overcome in the following manner. Some ground is laid thinly and evenly on a piece of plate glass, and a roller alternately passed over this and over the plate, until the latter bears a sufficient ground. This should be done with the plates cold, until the operation is completed, when the oil of lavender can be driven off the copper by a gentle application of heat until the plate shines and the ground becomes hard. In carrying out this operation, the nature of the line made on the copper by the mordant must be borne in mind. This is not V-shaped, but, in section, somewhat wider at the base than on the surface of the plate, the edges being undercut to some extent by the acid. Advantage may be taken of this quality when the lines are over-bitten and print too dark; for, with a burnisher used with oil, their edges may be squeezed together and so made to hold less ink and print lighter. Additional work may, at any stage, be put on the plate with the needle, after re-grounding, and a local effect can be produced by applying the acid with a feather instead of placing the whole plate in the bath.

5. FROM A LINE ENGRAVING BY B. P. GIBBON, AFTER A. COOPER, R.A. (Working proof from unfinished plate)

Ink Distribution. The plate should now be ready for printing, which is done in a copperplate printing-press, exerting such pressure as to drive the paper into every depression in the copper, and extract the ink therefrom. The ink used is made from any pigment with sufficient body, ground rather stiffly with burnt linseed oil; umbers or ochres being preferred for colour, and Frankfort black, heavy French black, or a lighter black, made from the smoke of burning paraffin oil, for the blacks. The two former are used for giving "body" to the ink, and the latter for blending to obtain special qualities of printing. A great deal depends on the printing of an etching. If the plate is cleaned as bright as possible, by means of the palm of the hand charged with ink and whiting, only the bare lines show, as in a visiting-card. But it is perfectly legitimate and very valuable to arrange the ink on the plate in such a manner as to get much richer effects. In such a case, the ink is again worked with the palm of the hand, but with a gentler pressure so as to leave more of it on the plate outside the lines.

A further effect may be obtained by *retroussage*, the dragging of the ink into desired directions with a piece of soft muslin, which is lightly drawn over the heated plate along the lines, following the hand and bringing a portion of the ink over the edges of the lines. This process softens them and makes them print darker than would otherwise happen. By careful arrangement of the ink in these ways, a considerable amount of tone may be produced, but the process has to be repeated, necessarily, for each print. The plate must be kept warm over a "heater" in order to soften the ink, which is first applied thickly with a dabber; the surplus ink is then removed with a pad, and the final arrangement of it given with the palm of the hand as just stated. The paper should be of good quality—old hand-made rag paper is the best—and both soft and tough. It is used damp. At every stage of etching, the temperature must be taken into account. The student should study carefully the etchings of Rembrandt, Vandyck, Hollar, Méryon [7], Whistler (the "Thames Set" in particular), and Sir Francis Seymour Haden, P.R.E.

6. WINDSOR FROM ETON (From an aquatint by Paul Sandby, 1777)

In the soft-ground etching process, ordinary etching ground is used, mixed with half its weight of lard or tallow. The ground is laid and smoked, as already described. When cold, a sheet of thin paper is strained over it, and upon this the drawing is made with a lead-pencil, which causes the ground to adhere to the paper in a broken line, depending upon the grain of the paper, the hardness of the pencil, and the pressure used. The plate is then bitten and printed in the same manner as an ordinary etching, the result being a singularly faithful reproduction of a pencil line. Some good examples of this method can be seen in

the work of Samuel Prout, but, at the present time, it has almost ceased to be practised.

Dry-point. A form of engraving which is usually classed with etching is produced by ploughing up the copper with a steel or diamond point in such a manner as to leave the upturned metal in a ragged edge or " burr " on the side of a furrow. For this purpose the tool is sharpened to an obtuse angle. No acid is used, the burr holding most of the ink which gives the printing quality to the plate; if the latter were removed, the line would print sharp and clean. Dry-point is sometimes used alone, but more often as a means of finishing an ordinary etching, it being capable of an effect of great richness of black. The plate worked in this manner is only capable of comparatively few impressions, as the pressure of printing soon flattens out and destroys the burr.

Etching Limited to Pure Line. In all the processes of etching it should be remembered by the beginner that he is dealing with pure line, and that, within this limit, the art registers the precise work of the artist. In a reproduction of a picture the aim should be to express in line the intention of the painter, and not to imitate the texture of paint. In the selection of a subject, one lending itself to a bold or graceful arrangement of line rather than of mass, or tone, will always be more satisfactory, and the merit of an etching lies more often in what is omitted, but still suggested, rather than in an extreme of finish. If the right hint is given by the etcher, the eye of the beholder cannot fail to fill in the scheme offered to him with absolute certainty and rare pleasure. The mistake must never be made of confusing an etching with a pen-drawing.

7. LA POMPE NOTRE DAME, 1852
(From an etching by C. Méryon)

Aquatint Etching. This is a method of etching which resembles that already described, so far as it is the result of biting-in a drawing upon copper with acid, and when once the plate is prepared, it exactly resembles it in the process of printing. But the essential difference between this class of print and etchings lies in the fact that in pure aquatint there are no lines. Everything is expressed in tones, as in a wash drawing, of which, indeed, it may be considered the engraved equivalent, as etching is that of pen drawing. This being so, there is no use for needle or graver. The biting-in is done by washes of acid applied with a brush, on a ground having certain necessary characteristics. And the preparation of this ground is, therefore, the first thing to be considered.

The principle underlying the various ways of obtaining an aquatint ground will easily be understood when it is remembered that the smooth surface of an unused plate will not hold ink for printing. It must be roughened in some way. To begin with, therefore, we require, for the purpose of painting acid on the plate, an even printing surface all over it. This is obtained by breaking up the surface into minute dots or reticula- and can be effected by several methods of laying a preliminary ground, followed by acid biting.

Grounding the Plate. In one case, an ordinary etching ground is first laid upon the plate, which is then heated till the ground becomes soft. Upon this finely powdered salt is next sprinkled evenly. The salt sinks through the soft ground, until it reaches the copper. The ground is then allowed to become cold and hard again, when the salt can be dissolved out with water, leaving the ground pitted minutely wherever it rested. If the plate is now bitten in the acid bath, each of these pittings will produce a black dot. Another method, conveniently known as sand-ground aquatint, is to cover the hard ground with sand, or, better, with emery paper, and pass the plate two or three times through a printing press.

But more convenient than these are the processes known as the " resinous dust ground," and the " spirit ground." In the former, finely powdered resin or asphaltum is placed in a box, which is then shaken rapidly or revolved until a smother of the dust is produced inside. The plate is then inserted at the bottom of the box—and allowed to remain until the dust has settled in an even layer on its upper surface. It is carefully withdrawn, and heated gently, but not enough to melt the dust, a proportion of which will be found to adhere to the plate. The superfluous dust is blown away, and the plate, if bitten, will show a covering of infinitesimal white dots where the particles of resin or asphaltum adhering to it have protected its surface against the action of the acid. This method gives good results, but requires careful manipulation and a specially-made box, with an aperture and door for the insertion of the plate.

The most convenient of all ways of making an aquatint ground is by taking advantage of a curious property of resin. This is dissolved in rectified spirit, and flooded evenly over the plate. As it dries, the resin held in solution is again deposited, and contracts into a series of reticulations, each of which, if bitten, will be represented by a fine line where the acid has penetrated the " crackle " of the resin. The granulations produced will become coarser as the proportion of resin used is increased.

The Aquatint Picture and its Limits. In the making of the picture the high lights are first stopped out with Brunswick black. Acid, as already stated, is applied with a brush, each tint being similarly protected as finished, and the whole completed by successive steps in this manner, leaving the deepest shadows to the last. The method of printing is identical with that of an etching. Pure aquatint, as thus described, is by no means capable of a wide range of expression, although, for certain effects of landscape, it has unrivalled qualities. But its flatness of tone limits it to a considerable extent, and many artists have reinforced this by using a preliminary basis of strongly etched lines, put upon the plate before the

aquatint ground was laid. The history of the art begins with Jean Baptiste Leprince about 1750, although earlier suggestions of it are to be found. It was introduced into this country by the Hon. Charles Greville, who communicated it to Paul Sandby, R.A. This artist made the first English aquatint, in 1774, and his work [6], together with that of William Daniell, R.A., J. C. Stadler, R. and D. Havell, and F. C. Lewis, may usefully be referred to by the student. An aquatint plate, it may be noted, has good printing powers, and is capable of producing a large number of impressions without serious deterioration.

Line Engraving. The old and beautiful art of line engraving is now almost entirely abandoned; but its revival always remains possible. The technique of it is quite simple, but it requires a patient skill only attainable by long practice. It is to be remarked, in the first place, that the term "line engraving" is used to denote only engraving upon a metal plate, made with a special instrument—the burin [1]—which may be described as a short steel tool, curved upwards towards the point, square in section, but grooved on each face, and fitted with a knob handle suitable for holding within the palm of the hand. In the ordinary meaning of the words "line engraving," they might be applied to etching, dry point, or woodcuts; but the custom of ages sanctions the above limitation, which is universally accepted.

All the old engravings were made upon plates of copper until the early part of the nineteenth century, when steel was largely substituted for the softer metal, the term "steel engraving" thus coming into vulgar use almost as a synonym for that forming the title of this section. In pure line engraving no tool other than the burin was used. The subject was first lightly sketched upon the plate, and then gradually finished, the practice of most engravers having been to work from light to dark, gradually filling in the shading as the task progressed [5]. The burin was held in the palm of the hand, guided by the finger and thumb, and driven forward against a pad with considerable pressure, cutting a line almost free from burr [4]. But many engravers made use of the process of etching as a convenient means of getting the outlines of their subjects upon the plate, biting-in lightly, and re-working the lines with the burin.

How the Masters of Line Used its Limitations. At a very early period in the history of the art the dot makes its appearance as an adjunct to the pure line, and this is most easily made with a burin having its point curved downwards instead of up. The old masters kept their work open, using simple shading only to express form. Close cross-hatching—that is, lines crossing and re-crossing each other closely at varying angles—was a development due to attempts at realising the tone, and light and shade, of a painting or wash drawing. In this later work, the dot is used to strengthen, or as a substitute for the cross-hatching, instead of being simply a device to secure a softer effect than line was capable of giving.

The great characteristic of burin work is that it produces only a formal line or line and dot, as compared with the unfettered freedom of the etching. It will turn only in a curve, and thus imposes severe limitations on the skill of the engraver. The great masters of line, such as Dürer, Lucas Van Leyden, Mantegna, Marc Antonio, and our own William Rogers, were able to use this characteristic to splendid advantage, and the leaders of the Dutch and French schools—as, for example, Cornelius Visscher, Nanteuil, and the Drevets—while losing much of the intrinsic value of line, quite compensated therefor by the superb modelling and light and shade with which they invested their portraits. After the close of the sixteenth century line engraving was chiefly devoted to the reproduction of paintings; and the student of this class of work should not rest content until he has made himself acquainted with the admirable engravings which were produced in England by the artists associated with J. M. W. Turner, absolutely the finest landscape engraving the world has ever seen. It was usual to take proofs of the plates in various stages of completion. An interesting series of these can be referred to in the collection of prints and drawings in the Victoria and Albert Museum.

Stipple Engraving. This was a method much used in the second half of the eighteenth century. In it the whole of the picture is represented by dots, carefully placed, at wide or close intervals, to express the modelling and light and shade of the design. These dots were generally made with a needle upon a plate covered with an etching ground, and, when bitten in, deepened and finished with the burin. For this purpose, as already remarked, the burin has a downward point. The roulette, a small wheel with toothed surface, and tools consisting of groups of two or more points, were also employed. A combination of cut line and stipple is also frequently met with. A special form of stipple used particularly for the facsimile reproduction of drawings has received the name of "chalk engraving." It was executed partly with soft ground etching and partly with roulettes and punches. The best examples of stipple engraving—which was frequently printed in red or brown—are to be found in the work of F. Bartolozzi, W. W. Ryland, A. Cardon, G. Vendramini, and L. Schiavonetti.

Colour Prints. Mezzotint, aquatint and stipple, and even line engravings, were frequently printed in colours, the inks used being of the same nature as described above, but with the addition of pigment. Too often the use of colours was merely a device to disguise the wearing of the plate, and although a pleasing effect is produced in the best examples, this defect should always be watched for by the collector. The colours were arranged, as required, on the plate for each separate impression, and it is impossible, as a consequence, to find two prints in colour from the same plate, that exactly correspond in the minutest details.

It is fairly easy to detect the extent of handwork which appears on a coloured aquatint or engraving. If it be examined with a lens, the spaces between the engraved dots or lines will appear white in those parts wherein the colour was printed; but where applied by hand, the wash covers everything. Good examples of coloured mezzotint and stipple are to be found in prints by the Wards and J. R. Smith—especially those after Morland; of coloured aquatint by W. Daniell and the Havells; and a good print of pure line engraving, printed entirely in colours, may be referred to—"A Sleeping Venus," by P. W. Tomkins, after Titian. In France and Germany a good deal of attention is now being given to the production of coloured etchings. In these, the method of printing is that already indicated, but it should be borne in mind that the colour is an integral part of the composition from its inception, and the actual etching is subordinated thereto accordingly.

Continued

WHAT WE SEE IN THE HEAVENS

Group 13
ASTRONOMY
1

Following
COMMERCIAL GEOGRAPHY
from page 6006

How and Why the Stars Rise and Set. When and Where the Principal Constellations may be Found. The Solar System

By W. E. GARRETT FISHER

ASTRONOMY deals with the celestial bodies, among which the earth is one of the least; it teaches us their physical constitution, and traces the history of their development. It is probably the oldest of the physical sciences. Its foundations were laid when shepherds watched their flocks by night on the plains of Chaldea, and occupied their nocturnal leisure by studying the recurrent march of the stars. As good a way as any to begin the study of this fascinating science is to put oneself in the place, as far as possible, of these earliest astronomers. Those who live in a town, which in our modern civilisation is the lot of the majority, are less favourably placed for this study than those whose life is passed under the clear and open skies of the country; but there are few towns so foggy or so shut in that the diligent student cannot find some point of vantage in his near neighbourhood from which, on a cloudless night, an open view can be obtained of a large part of the sky.

The Motion of the Starry Sphere. After watching the starry heavens for a few consecutive nights during the same hours—say, from nine to twelve—the student will realise, first of all, that there is an apparent revolution of the whole heavens. He will notice that the bright stars, which are scattered irregularly over the whole visible sky, appear to form themselves into certain more or less definite patterns, known as *constellations*, and that these patterns continue to preserve the same relative arrangement from night to night [1]. But careful observation for even so short a time as three hours in a single evening will further show him that the whole starry sphere is in steady motion.

Stars which appear early in the evening low down near the eastern *horizon*, or boundary line of our vision, gradually climb up into the sky, whilst those which were originally sloping towards the west sink further and further down, and ultimately disappear below the western horizon. Their motion is precisely the same as that of the sun, which, as everybody knows, rises in the morning above the eastern horizon, gradually ascends until it has reached its highest point, and is practically due south at noon, and then descends until it sets or sinks again out of sight behind the western horizon.

The Daily Revolution of the Earth. We are familiar with this apparent motion of the sun, but so little accustomed to watch that of the stars through anything like the same space of time, that at first we hardly associate the two. But the first lesson which should be learnt by the watcher of the sky is that the stars behave just like the sun, and pass from the eastern to the western horizon in a space of time which is constant for each of them, though it differs in the case of every individual star. The real meaning of this fact is, of course, that the earth revolves on its own axis once in about twenty-four hours. We who live on its surface are unconscious of the motion which we partake, and consequently are apt to talk of the sun and the stars as if they moved round the earth. This was the theory actually held by all men till the middle of the sixteenth century, and all early systems of astronomy were occupied in accounting for the motion of the stars as if the earth was at rest in the centre of the universe.

The Sidereal Day. After observing the stars for a number of nights—not necessarily consecutive, for a great deal may be learnt by taking a single evening a week for the purpose — the young astronomer will next notice that he has to distinguish between two distinct kinds of heavenly bodies. The great majority of the stars which bedeck the evening sky remain always fixed in the same relative positions to one another. They swing steadily round the earth at such a rate as to complete one revolution in rather less than twenty-four hours. That the period of their revolution does not exactly coincide with the measure of time which we call a day is clear, indeed, from the fact that the configuration of the stars is not the same at the same hour on every night throughout the year, as it would be if this were the case. The stars which at one time are high up in the sky are seen at another low down on the horizon, whilst some of the brightest stars are visible in winter but not in summer. The *sidereal day*, or period during which any particular star completes its revolution and comes back to the same place is about four minutes—exactly 3 minutes 55·91 seconds—shorter than the *solar day*, or interval of time between successive noons. This sidereal day is the rotation-period of the earth. Consequently, any particular star comes back to its place each night rather earlier than on the night before.

For convenience, we measure the apparent motion of the stars from the moment at which they cross the *meridian*, an imaginary great circle which is drawn on the celestial sphere through the pole of the heavens and that point of the horizon which is due south of the observer. If a particular star happens to cross the meridian at ten o'clock on a particular evening, the next night it will cross the meridian about four minutes earlier. The actual difference between the sidereal and the solar day is such that, after a year has elapsed, any star coming to the meridian four minutes earlier every night will then have returned to the place which it occupied a year before at the same hour of the night. In other words, the year contains 365¼ solar, and 366¼ sidereal days. Hence the configuration of the stars as seen at the same instant of time on a particular night in every year is the same; or at least it would be so if there were not other small but long-continued variations to take into account, with which the student need not trouble himself at present.

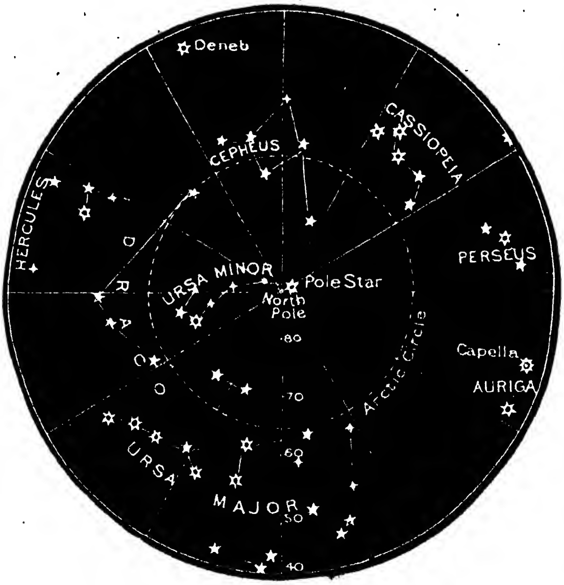
Planets and Other Wanderers. This is the rule with most of the stars visible in the sky. But there are a few exceptions to it. The student will soon find that there are about half-a-dozen stars, and those among the brightest which he can see, which do not obey this otherwise universal law. Instead of returning night after night to the same position, they appear to wander among the other stars, and to occupy positions which differ

considerably at different seasons. These are known as *planets*, or wandering stars. Venus, the brightest of them all, is known to everybody as the Evening Star or the Morning Star, occupying both positions at different times of the year. Jupiter, which is the brightest star in the sky after Venus, is another of the conspicuous planets. Mars, the red planet, is also well known to everybody who watches the night sky. Mercury and Saturn are less familiar, whilst Uranus and Neptune and the minor planets, nearly 600 in number, are never seen without a telescope.

The moon, which is far brighter and larger than any of the stars, also holds a wandering course, both its position and its brightness varying from day to day through the month. Comets and shooting stars, which also appear in the sky, show themselves at apparently quite irregular intervals, though we shall see later that they also are subject to the reign of universal law.

Nightly Motions of the Fixed Stars. We shall now confine ourselves to studying the so-called *fixed stars*, those stars, namely, which preserve the same relative position and configuration from night to night, only varying, and that with perfect regularity, in the times at which they reach the meridian. For this reason they have been known from the dawn of astronomy as fixed stars, in contrast with the planets or wandering stars. The student who watches the nightly changes in the sky with close attention will soon perceive that all these fixed stars appear to move in circles or parts of circles. Some of them describe larger circles than others, and the further south a star is when it passes the meridian, the larger circle will it describe.

If we look north, it will not be long before we satisfy ourselves that the *constellations*, or groups of stars, in that quarter of the sky describe circles which would be complete could we watch them through the twenty-four hours. The brilliant light of the sun blots them out of sight when it is above the horizon, and thus we can only follow them through a part of their diurnal path. But this part is always a segment of a circle, and at different times of the year we can watch them in different parts of the same circle, so that we infer that they actually complete the circle daily in somewhat less than twenty-four hours. They can actually be watched doing this by Arctic travellers in latitudes where the sun remains out of sight, and there is perpetual night, for several months at a time.



1. CIRCUMPOLAR CONSTELLATIONS

The Pole Star. There is one star, however, which appears to the naked eye never to move at all. This is known as the Pole Star, and the first aim of the student should be to discover it for himself. It lies due north, and its height above the horizon is always equal to the latitude of the observer's position. Thus, at the North Pole, the Pole Star would appear to be directly overhead, or in the *zenith*; at the Equator, it would be exactly on the horizon, though practically it would always be invisible; to a London observer, it appears to hang at an altitude of a little more than 51°. If the student will now procure a small model of the terrestrial globe, he will speedily perceive the meaning of this fact observed about the Pole Star.

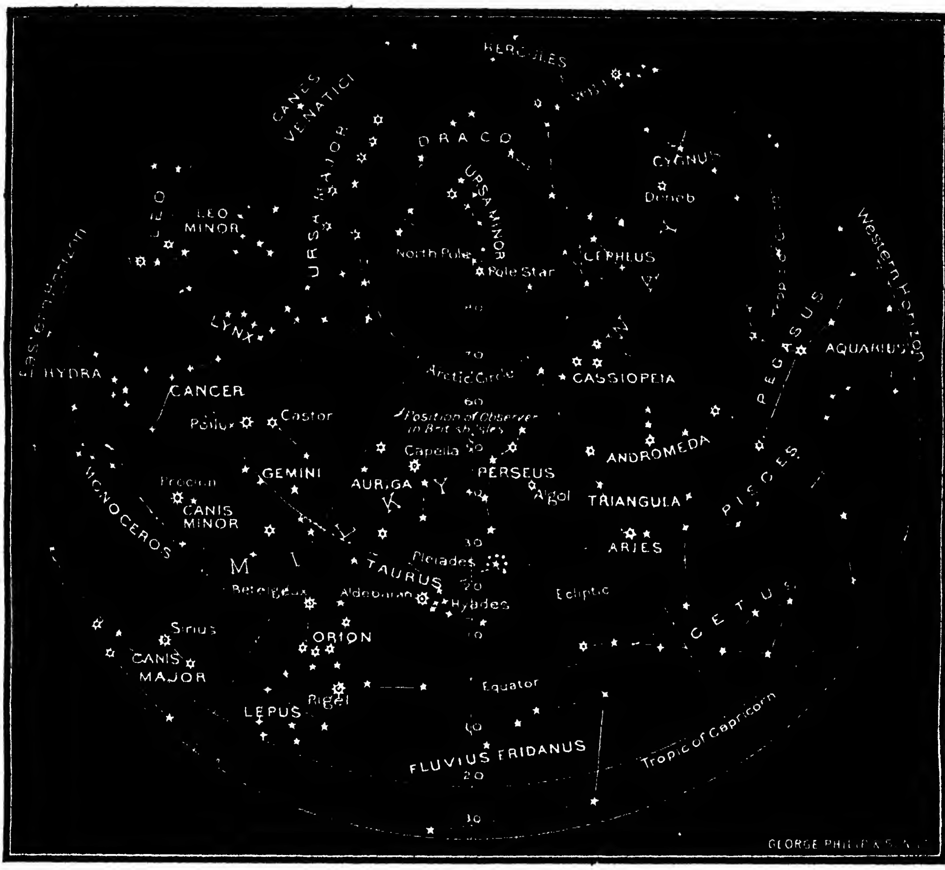
The Celestial Poles. The *poles* of the earth are the points at which its imaginary axis emerges, and when prolonged indefinitely this axis cuts the imaginary sphere of the heavens in two points, which are known respectively as the *north* and *south celestial poles*. If we now cause our model globe to rotate, keeping the axis pointing in the same direction, a little thought will make it clear that, to an observer on its surface, the stars, which are supposed for convenience to be fixed on the surface of an exterior globe, will all appear to describe circles round these celestial poles. These circles will vary in size with the star's distance from the pole; and if one of these stars happens to occupy a position corresponding to a celestial pole, it will appear to remain stationary to the terrestrial observer.

That is the case with the Pole Star, which, indeed, is not absolutely coincident with the celestial North Pole, but is so near to it that the tiny circle which it describes in its motion can be measured only with the aid of a telescope. To the naked eye it appears to remain motionless night after night, and thus provides us with a simple method of ascertaining the true North, as well as fixing the centre round which all the other stars appear to revolve.

It cannot be too often repeated that this motion of the stars is only *apparent*, being due to the *real* rotation of the earth, along with the observer on its surface, in the contrary direction.

There are about three thousand stars visible to the naked eye in our latitude, though not all these are visible at the same time, many of them being below the horizon whilst others are elevated in the sky at different times and seasons.

From a very early period they have been mapped out for convenience into definite figures, or *constellations*, to which more or less fanciful names have been adapted. The student must familiarise himself with the general names of these constellations, which he can easily do with the aid of any good star atlas, many of which are now published. Messrs. Philip's planispheres may be specially recommended. It is frequently by no means easy to recognise why these constellations have received their individual names, which often involve a great



2. CONSTELLATIONS VISIBLE IN AUTUMN

deal of imagination on the part of the observer. Most of them have come down to us from the earliest times when astronomy was studied in the valley of the Euphrates.

The Circumpolar Constellations. We shall begin by describing the *circumpolar* constellations, which are nearest to the Pole Star, and which never set in our latitude. In other words, they are visible at all times of the night and at all seasons of the year, though in different months they occupy different positions.

The most famous and familiar of these constellations is the Great Bear, which is also known as the Plough or Charles's Wain. It consists of seven bright stars arranged in the shape of a saucepan with a bent handle, from which our Transatlantic cousins have given it the more comprehensible name of the Dipper—American for saucepan. The two stars which form the side of the saucepan farthest away from the handle are known as the Pointers, because they furnish a ready means of finding the Pole Star, which lies in a straight line with them. On the opposite side of the Pole Star, and about equally distant from it, can be seen the constellation of Cassiopeia, shaped like a very irregular W. If we imagine a circle drawn round the Pole Star, passing through the Great Bear and Cassiopeia, and divide its circumference into four parts, we shall find two other conspicuous constellations occupying the two remaining quadrants. These are Auriga, or the Charioteer, and Lyra, or the Lyre. Each of them is distinguished by a star brighter than any which we have yet seen—Capella, in Auriga, and Vega, in Lyra. The latter star may be readily distinguished by its steely blue lustre, whilst Capella is more of a yellowish colour, and both surpass in brightness all other stars in the neighbourhood of the Pole.

The curious river of stars, crowded so closely together as to shine with indistinguishable lustre, which is known as the Galaxy, or the Milky Way, will be noticed meandering round the Pole from Auriga through Cassiopeia till it almost touches Vega, and thence flowing off in both directions to make a great circle in the heavens.

Extrapolar Constellations. The four constellations which encircle the Pole Star are always visible in our latitude, but as we go further south we find that the constellations move in larger and larger circles, until they dip beneath the horizon and disappear from sight. If we draw a circle round the pole at such a distance as just to touch the horizon, all the stars within this circle will be perpetually visible, and it is therefore called the *Circle of Perpetual Apparition.* Its distance from the pole depends upon the latitude of the observer.

It is quite impossible within our limits to give a detailed account of all the constellations which lie outside this circle and are visible to us at one time of the year but not at another. We may simply name some of the most conspicuous of these constellations, with the time of year at which

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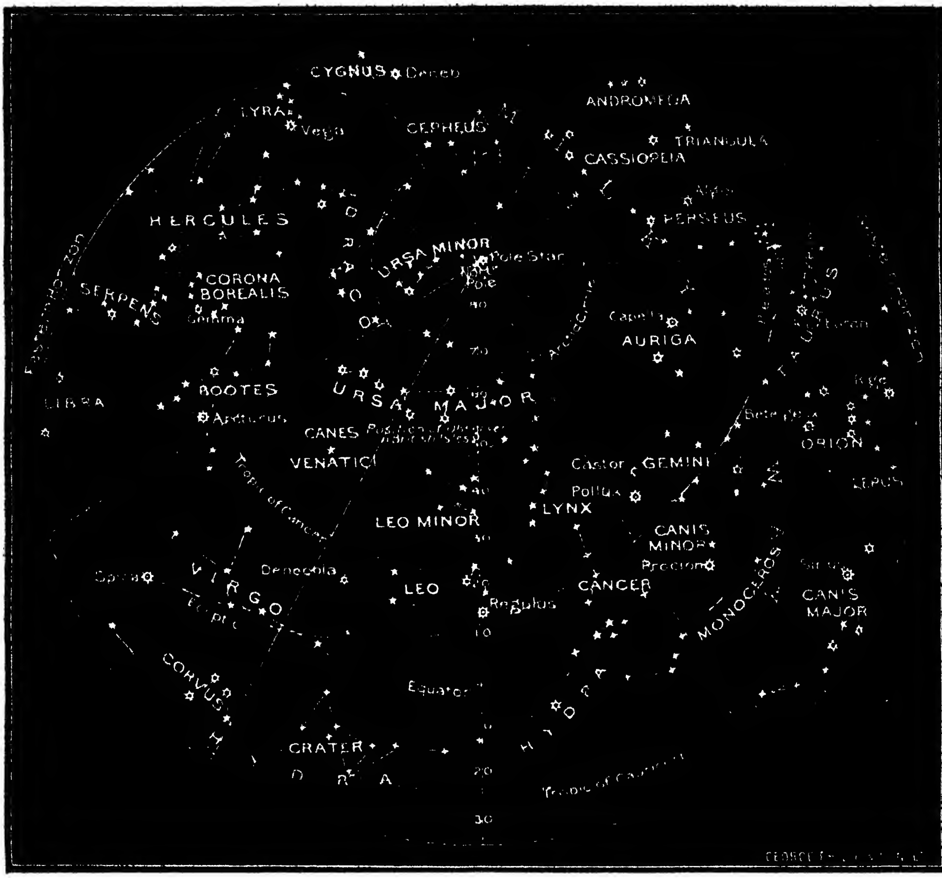


8. THE CONSTELLATIONS OF WINTER

they are visible in our latitude and the most brilliant stars which they contain.

Seasonal Constellations. The chief constellations visible in autumn are Taurus, or the Bull, containing Aldebaran and the Pleiades; Orion, the most splendid of all constellations visible in this country; Canis Major, marked by Sirius, or the Dog Star [2].

Constellations visible in winter are Canis Minor, the Little Dog, containing the brilliant star Procyon: Gemini, or the Twins, containing the bright stars Castor and Pollux; Leo, or the Lion, marked by the bright star Regulus [3].

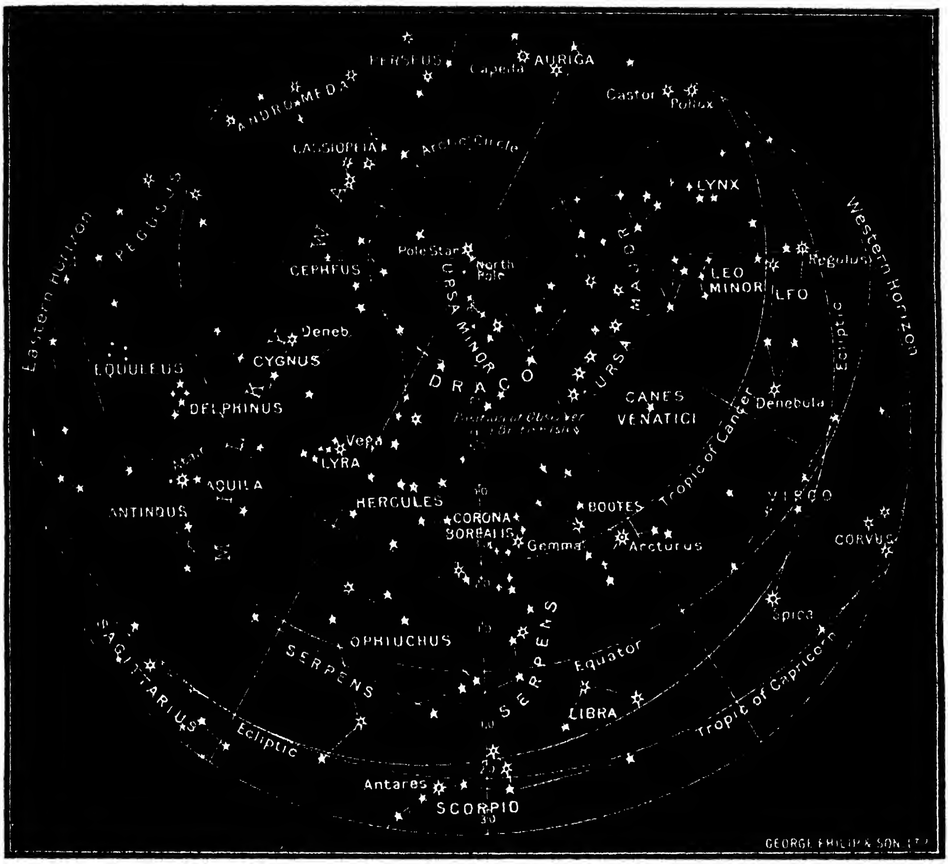
Constellations visible in spring are Boötes, or the Herdsman, marked by the bright star Arcturus, lying in the prolongation of the curved handle of the Dipper, or tail of the Great Bear; Virgo, or the Virgin, containing the bright star Spica; Scorpio, the Scorpion, with the red star Antares [4].

Constellations visible in summer are Aquila, the Eagle, marked by the bright star Altair in the Milky Way; Pegasus, the Flying Horse, with its characteristic square pattern of stars [5].

These are only a few of the constellations into which the visible stars have been mapped out, and are mentioned here because they contain the brightest and most conspicuous stars. It is no very difficult task to learn to distinguish them, but this can be done so easily with the help of a star map that it would be a waste of space to give further directions here for their identification.

The student has by this time elucidated nearly as much practical astronomy as was known to the ancients. They discovered, by observations of the same kind as he has made, that the fixed stars appeared to revolve daily round the earth, that the Pole Star alone remained in the same place, and that this revolution was completed in a little less than twenty-four hours—the time occupied by the sun from noon to noon—so that a different set of constellations occupied the same part of the sky at different times of the year.

The Ptolemaic System. They accounted for these phenomena, however, by supposing that the stars were really in motion round the earth, and were fastened on to the surface of a vast transparent or crystalline sphere with the earth in its centre. Other concentric and invisible spheres were introduced to account for the apparent movements of the sun, moon and planets, each of which was supposed to have a sphere of its own, moving in some curious fashion which accounted for the observed facts. In this way Ptolemy of Alexandria and his successors formed a highly ingenious and complicated system of astronomy, which was quite competent to explain the actual motions of the various planets with as much accuracy as was required by observations made entirely with the naked eye, and even to predict their future places. Ptolemy was quite aware that the earth was a globe, and that it was exceedingly small in comparison with the distances between it and the



4. CONSTELLATIONS VISIBLE IN SPRING

stars. But it never seems to have occurred to him that it was very much simpler to suppose that the earth was itself rotating than that these gigantic spheres, bearing the fixed stars and all the planets, were sweeping round it with the terrific speed that would be necessary for the outermost of them to complete one revolution in every day.

The Copernican System. The real state of things with regard to the planetary and stellar motions was first taught by Copernicus, a Prussian monk, who was born in 1473 and died in 1543. He was the first who clearly conceived the true system of the universe [6]. He demonstrated that the diurnal revolution of the heavens was only an apparent motion, corresponding to the real rotation of the earth on its own axis in the same period; that the earth, instead of being the centre of all things, was merely one of the planets, revolving in an orbit round the sun; that the sun itself was only one of the numerous stars which bedeck the heavens with light, and that these stars were at a distance from the earth which was very great in comparison with that of the sun or the planets. He also showed that the apparent movement of the sun and moon among the stars could be explained by supposing that the earth revolved round the sun in a year, and that the moon revolved round the earth in a month.

Copernicus first enunciated this great truth, which is now familiar to every schoolboy, but to work it out completely was reserved for a series of astronomers. The accurate observations of the Dane Tycho Brahé, the laws of planetary motion which the German John Kepler based upon them, the discovery of the telescope and the laws of motion by the Italian Galileo Galilei, and finally, the great discovery of the law of universal gravitation by our own Sir Isaac Newton, were all necessary before astronomy could become an exact science.

The Diurnal Motion. A little thought will show the student how it is that the real motion of the earth on its own axis gives us the effect of an apparent motion of the whole universe round the earth. If he stand up in the middle of the room and turn slowly round, the effect will be exactly the same as if the walls of the room stood upon a turntable and had revolved while he stood still. He knows quite well that it is he himself who is turning round. But in the case of the earth we are entirely unconscious of its motion, because we ourselves and all the objects which surround us, including the atmosphere, share in it. Motion, of course, is only relative—that is to say, we can only detect it by reference to some fixed point. So it is with the spinning earth. It is constantly rotating with a speed which, at a point on the equator, amounts to over a thousand miles an hour; but this rapid motion is quite imperceptible to us, since we share it, until we look at some external object like a star. There is really nothing but probability to show us whether we are moving in one direction or the stars are moving in the opposite one. During the greater

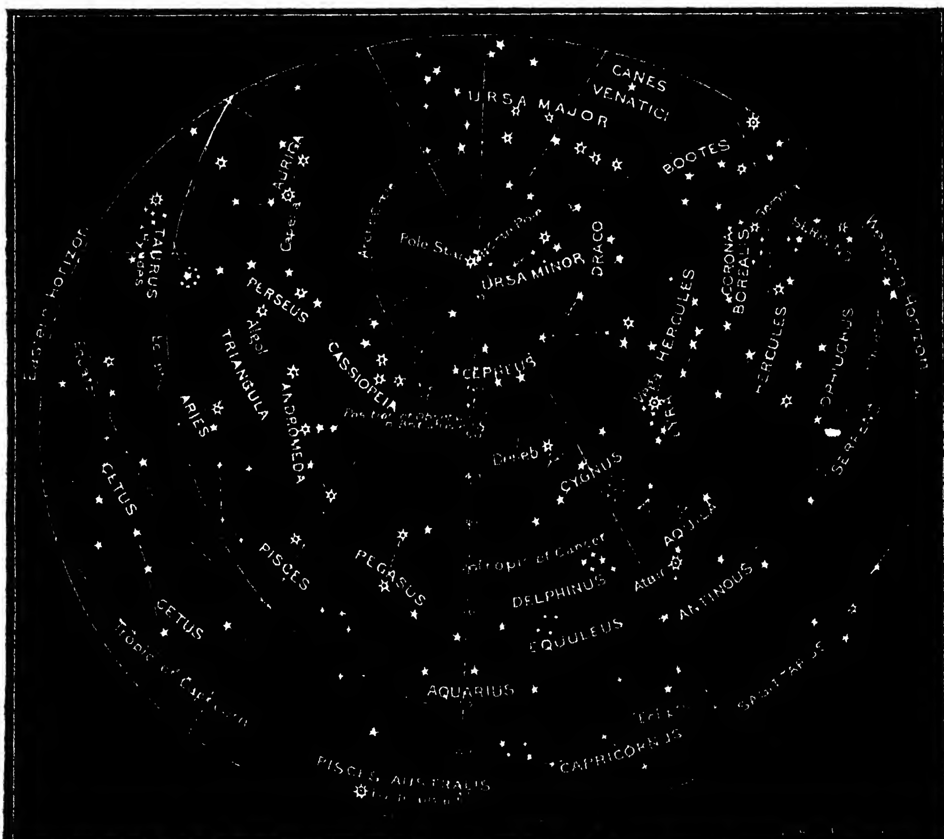
part of the existence of mankind the latter view was universally accepted. Now, however, we are all convinced that the former is the true one.

The earth rotates on its own axis once in 23 hours 56 minutes 4·09 seconds, and consequently in the same period the stars appear to complete a revolution in the opposite direction. The exact length of this period is determined by measuring the interval which elapses between two successive passages of the same star across the meridian, and, of course, it proves to be the same whatever star we may choose.

The Earth's Yearly Journey. In addition to the diurnal motion of rotation, the earth has another quite independent motion. This we deduce from the apparent motion of the sun. Our luminary appears to describe a great circle among the stars in the course of a year; this circle is known as the *ecliptic*. By the same method of reasoning previously employed it will be seen that the appearances would be just the same if, instead of the sun travelling round the earth, the earth travelled round the sun; and this is the explanation now adopted. Its accuracy is proved by certain physical considerations which lie beyond the sphere of this course. The earth, in fact, is one of the planets attendant on the sun, and travels round that star in an orbit which is nearly circular, but is actually an ellipse, at a distance from it which averages rather less than 93,000,000 miles. It always travels in the same plane, which is known as the *plane of the ecliptic*, and is inclined to the plane of the earth's equator at an angle of about $23\frac{1}{2}^\circ$. It is the combination of this orbital motion with the earth's diurnal rotation which, as we have seen, causes the stars to present different configurations in the heavens at the same hour at different times of the year. In the course of its journey round the sun it will be clear that the earth makes one additional revolution on its own axis; in other words, it makes $366\frac{1}{4}$ revolutions with regard to the stars in the same time as it makes $365\frac{1}{4}$ with regard to the sun. Thus, every star comes back to the meridian to-night rather less than four minutes before the solar time at which it arrived last night.

Solar and Sidereal Time. Hence it follows that there are two distinct methods of measuring time. They both depend upon the earth's rotation, which continues at an unvaried rate—or, at least, the variation which is believed to exist is so small that it is quite imperceptible within the span of man's history. The actual period of the earth's rotation, as measured by the interval between two successive appearances of the same star on the meridian, is known as a *sidereal day*, divided into 24 sidereal hours, minutes and seconds.

The *solar day*, however, is measured by the interval between two successive meridian passages of the sun—or, rather, since the sun's motion is not quite uniform, between two meridian passages of a fictitious body known as the *mean sun*, which is never more than a minute or two in front of or behind the real sun, but is so chosen



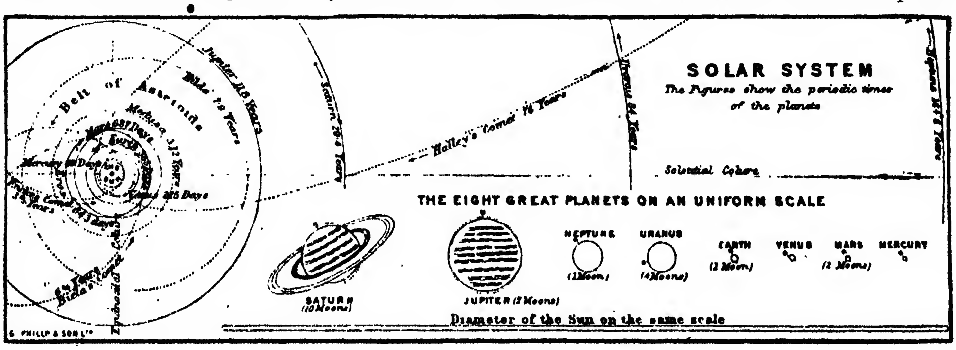
5. THE CONSTELLATIONS OF SUMMER

that every day is of exactly the same length. This day, as every one knows, is divided into 24 solar hours, minutes and seconds, which are those measured by ordinary clocks and watches. Astronomers use clocks which are regulated to keep *sidereal time*, and consequently register 24 hours while an ordinary clock only registers 23 hours, 56 minutes, 4·09 seconds.

The sidereal and mean solar time are in agreement on March 22nd, and for the rest of the year the sidereal clock is steadily gaining until it catches up the solar clock at the same date next year. Thus, the same star always crosses the meridian at the same time by the astronomical or sidereal clock, and a simple calculation—multiplying the number of days which have elapsed since March 22nd by 3 minutes 55·91 seconds, and adding this to the time shown—gives the corresponding solar time. As astronomers do most of their work at night, they reckon the day from noon to noon, and divide it into 24 hours: thus 5 a.m. on June 23rd is spoken of by astronomers

which shine in the midnight sky. Its nearest stellar companion is situated at an almost incredibly vast distance, such that a body moving with the speed of light itself would take more than four years to cross the gap which divides the sun from the nearest star. The sun, with its attendant planets and their satellites, as well as certain comets and shooting stars which also circle round it, make up what we call the *solar system*, the study of which must be the first object of the astronomer. The far-off and innumerable stars form the subject of a later division of the science, known as stellar astronomy, with which we shall deal in a later section. But the greater part of this course will be devoted to the motions, movements, and physical characteristics of the bodies composing the solar system.

The Solar System. The centre of the solar system [6], of course, is the sun, that great luminous orb which supplies us with almost the whole of the light and heat which are necessary for the continuance of life, and which holds all the planets



6. THE COPERNICAN SOLAR SYSTEM

as June 22nd, 17 hours, Greenwich mean time. This must be remembered in consulting astronomical tables.

The Motions of the Moon and Planets. The moon, in addition to sharing the diurnal motion, also describes a circle among the stars, which it completes, from new moon to new moon, in the period known as a lunar month, or about 29½ days. This phenomenon is similarly explained by the fact that the moon describes a nearly circular orbit round the earth, at an average distance of 238,840 miles, in 27 days, 7 hours, 43 minutes, 11·55 seconds. The former period is known as the synodic, the latter as the sidereal month—the difference being due to the earth's orbital motion.

The other planets, like our own earth, describe elliptical orbits round the sun, at distances which vary from about 35,000,000 of miles in the case of Mercury, to 2,775,000,000 of miles in that of Neptune. The time which they take to complete this revolution varies from about 88 days to more than 164 years. It is the composition of these real motions which accounts for the apparent movements of the sun, moon, and planets.

The Sun a Star. The sun itself is a star, and by no means one of the largest among those

in regular motion about it by its vast gravitating energy. The sun is a star of comparatively small magnitude, which is yet so large that if the earth were placed at its centre there would be ample room for the moon to revolve round it inside the sun, and so massive that it outweighs all the planets put together more than 700 times.

The nearest planet to the sun is Mercury, at a distance of 35,000,000 miles. Next comes Venus, the bright evening star, at a distance of 66,000,000 miles. After these inferior planets follows the earth, distant 93,000,000 miles. The remaining planets, being beyond or above the earth, are known as *superior*, and include Mars, at a distance of 141,000,000, Jupiter 480,000,000, Saturn 881,000,000, Uranus 1,771,000,000 and Neptune 2,775,000,000 miles. Between Mars and Jupiter there is a curious swarm of minor planets, of which nearly 600 are known.

The earth has the moon for its single satellite, revolving round it as the planets revolve round the sun; and all the exterior planets have their satellites, varying in number from the one which circles Neptune to the ten which whirl round Saturn. In addition to these planets the sun has for attendants an unknown quantity of comets and meteorites.

Continued

Following CLOCKS & WATCHES from page 6084

SCIENTIFIC INSTRUMENTS

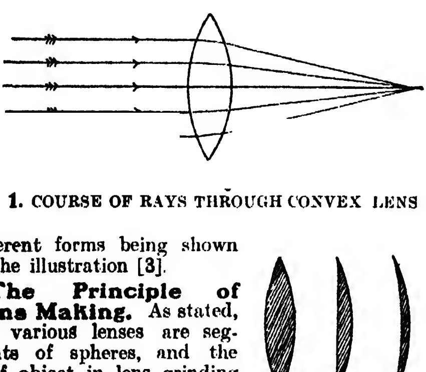
Lens Grinding. Principles and Manufacture of Optical, Meteorological, and Other Scientific Instruments

As lenses are important items in so many optical instruments it will be appropriate to consider them first. Lenses are the chief feature of microscopes, telescopes, lanterns, cameras, and spectacles, and the methods of manufacture of the various lenses have much in common. The material of which lenses are made is generally glass, although for spectacles pebble or quartz has several advantages. Pebble, however, in anything but the thinnest plates, such as are required in spectacle lenses, has a double refraction, hence it cannot be used in many optical instruments. The definition of a lens, as showing the difference between a lens and an ordinary piece of glass, is "a piece of glass or other transparent substance shaped so that rays of light passing through it are made to change their direction and to magnify or diminish objects at a certain distance." The illustration [1] is what is known as a convex lens, the straight lines representing light which, by the action of the lens, is refracted and converged to a point, called the *focus*. The second figure [2] is a concave lens in which the rays of light are diverged. It is obvious that a focus is not formed by this lens, but what is called a "virtual focus" is obtained by following the rays backwards as shown by the dotted lines, V being the point of virtual focus.

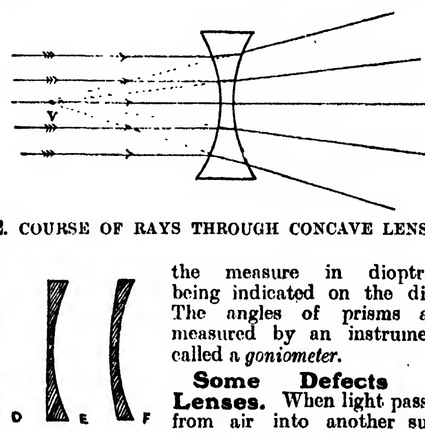
The various kinds of lenses must be imagined as segments of glass spheres or cylinders, the different forms being shown in the illustration [3].

The Principle of Lens Making. As stated, the various lenses are segments of spheres, and the chief object in lens grinding is to obtain truly spherical surfaces. This is fortunately comparatively easy on account of the natural tendency of two surfaces to grind each other equally when rubbed together, especially when the surfaces are paired—a concave and a convex surface. In order to grind or polish a lens surface a tool must be made of the exact shape of the lens required, this tool being moved over the surface of the lens in several directions, abrasion being produced by a small quantity of emery powder. It is obvious that in time the tool will have worn the glass away until both are of the same curvature. The comparatively rough surface—it looks like ground glass—is then treated with finer emery powder and finally putty powder until a brilliant surface or polish results. The curvature of the tool determines the curve of the glass and the curve of the glass is the chief factor in the magnifying or diminishing properties of the glass. Lenses made of different glass vary in their properties, so that by picking the kind of glass and the depth of the curves and combining the several lenses different effects are obtained.

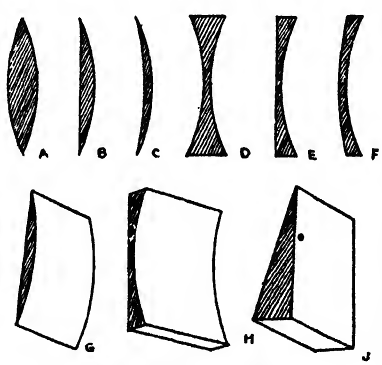
Measuring Spheres. The instruments used for measuring spherical lenses are called *spherometers*. One of the oldest is the Ross spherometer, shown in 4. It will be seen that the central index bar is moved up or down according to the convexity or concavity of the cylinder that is being measured. The index bar is provided with a vernier for finer reading. Professor Silvanus P. Thompson has also devised a spherometer, but the one chiefly used by spectacle makers is that invented by Mr. J. T. Brayton, a Chicago optician. This is, in size, like a watch, the appearance of the instrument and the internal works being shown in 5 and 6. It gives by direct reading the focal length of a lens either spherical or cylindrical, the measure in dioptrics being indicated on the dial. The angles of prisms are measured by an instrument called a *goniometer*.



1. COURSE OF RAYS THROUGH CONVEX LENS



2. COURSE OF RAYS THROUGH CONCAVE LENS

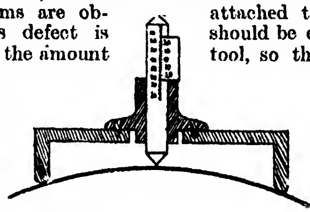


3. VARIETIES OF LENSES

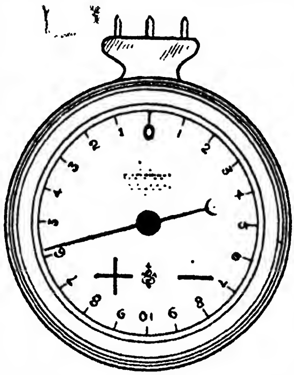
A. Bi-convex or equi-convex B. Plano-convex C. Convex meniscus or periscopic convex D. Bi-concave or equi-concave E. Plano-concave F. Concavo-convex or periscopic concave. G. Convex cylinder H. Concave cylinder. J. Prism

Some Defects of Lenses. When light passes from air into another substance of greater density it is bent or refracted. A familiar illustration of this is obtained when a stick is dipped into water, the refraction of light at the surface of the water giving rise to the impression that the stick is bent. Light is made up of a series of vibrations which together give the sensation of white light, but the component vibrations violet, indigo, blue, green, yellow, orange and red are bent or refracted in an

unequal degree. By means of a prism a beam of light can be separated into its component parts, the experiment being familiar to students of physics. A lens of spherical shape is really a collection of prisms, an idea which can be readily grasped by studying a section of a lens, and hence colour fringes familiar with prisms are obtained with single lenses. This defect is known as "chromatic aberration," the amount of difference between the refraction of the extreme colours being called the "dispersion" of the glass. To correct chromatic aberration is one of the most important functions of the opticians. Different kinds of glass have varying refracting powers, or dispersion, and by putting together differing glasses it is possible to neutralise or correct the defects of either, a lens so produced being *achromatic*—free from colour. Crown and flint glass are the commonest examples. A disc of each glass put together produces a lens free from colour defect, but obviously the positive and negative lenses must not be of corresponding strength or no lens effect will be obtained. The rule is that the foci of the two lenses should be proportional to the relative dispersion. A large number of various kinds of glass are now available, and the requisite proportions can be calculated when certain physical properties of each glass are known. Another defect—spherical aberration—is due to the shape of the lens and cannot be entirely corrected. It can, however, be reduced to a minimum. The nearer the surface tends towards the elliptical form the less aberration there will be, and by properly combining the curves of two lenses most of the aberration can be destroyed. Astigmatism is a defect in which a round point is rendered by an oval, the correction being made by keeping the lens as concentric as possible. Various distortions exist in lenses which are known as *barrel-shaped* or *pin-cushion*, according to the kind. These defects are neutralised by "stops," or diaphragms placed between the two lenses.



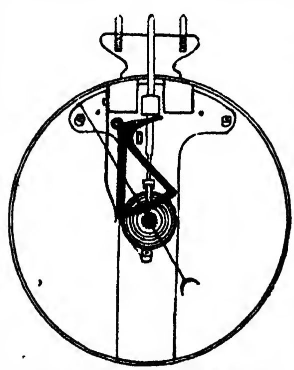
4. ROSS SPHEROMETER



5. BRAYTON LENS MEASURE (OUTSIDE)

The Manufacture of Lenses. The methods of making lenses will now be dealt with, but specific instruction in special classes of lenses will also be referred to under the various optical instruments.

Lenses are worked by hand or machine, the latter arranged to give motions similar to those imparted by the workman in the hand method. For persons who already have a lathe, a useful lens-grinding attachment is shown in **7**. It consists of a wooden box supplied with a curved arm inserted in the tool-rest support. A vertical journal box passes through the bottom of the box, and contains a shaft having upon its upper end a socket for receiving the grinding tool, and on the lower end a grooved wheel surrounded by a rubber friction band, which is revolved by contact with the face-plate of the lathe. The speed of the wheel relatively to that of the lathe can be varied by raising or lowering the shaft by means of the box support in the tool post. The glass to be ground is cemented to the face of a flanged casting, and is held down to the grinding tool by the lever attached to the box. The centre of the lens should be eccentric to the centre of the grinding tool, so that the lens will be revolved on the face of the tool. The point projecting from the lever enters a small cavity in the centre of the casting, to which the lens is attached, and ensures an equal pressure over the entire surface of the lens.



6. INTERIOR OF BRAYTON LENS MEASURE

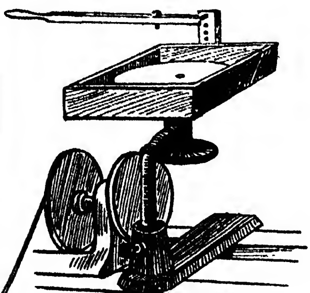
Gauges. The tools which must be provided first are the templates, gauges, or patterns for forming the curves of the grinding tools. For long radii, the gauges are sometimes cut out of thin plate-glass, say about $\frac{1}{16}$ in. thick, by cementing it upon the bench and mounting a good diamond upon the end of a radius bar. In its simplest form, the radius bar may be only a wooden rod, with a bradawl stuck through it into the bench, the diamond being placed from the awl at the distance equivalent to the radius of the curve. The glass is cut and separated, the edges of the two pieces being respectively concave and convex. These edges are ground together with emery and water by being laid upon the bench and rubbed edge to edge till they fit truly. More usually templates of large and medium radii are cut out of sheet brass, or even zinc, either with the radius bar or in the turning lathe. The brass concave and convex gauges are cut at separate operations as it is necessary to adjust the radius to compensate for the thickness of the edge of the cutter. The edges are ground truly together. A gauge made in a turning lathe, with bevel edges, is shown in **8**. The tools are turned to the brass gauge, sometimes only the concave tool, the convex one being turned from the perfect concave. Double calipers and step gauges are used for gauging the thickness of concave lenses in the roughing process.

Grinding and Polishing Tools. Having the templates ready, a concave "roughing" tool is next made. This, called a "shell," is needed for a convex lens, and is turned from wood, being gauged until true. A shell in iron is obtained by casting; at the same time another casting about $\frac{3}{8}$ in. larger is made, which serves later on as a medium for the polisher. A pair of brass tools [9], concave and convex respectively, are next made, and these being the tools that are responsible for the curves of the lenses, a good deal of time must be devoted to their preparation. The two tools must fit each other as accurately as possible. In lens factories this is carried out so exactly that when the two parts are put together the lower tool can

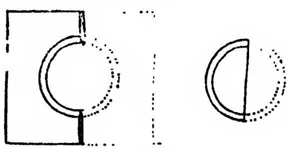
be raised by means of the upper tool. As mentioned above, the gauge is used for the concave tool, and from this the convex portion is shaped. The turning tool, or scraper, shown in **10**, is useful for giving the final shape to the concave tool. It consists of a sharpened steel disc attached to or formed upon the end of a bar. Drawn brass is preferable for the tools, as it is more homogeneous than a casting. The backs of the tools are provided with screws like an ordinary chuck, so that they can be fitted into the lathe mandrel for turning, and when required for grinding, fixed to a "post" or upright in the workshop. The brass tool must be made of sufficient weight to retain its "figure," without risk of flexure. To correct the curvature of the tools, the convex tool is fastened by the screw on the back to the post, and a handle having been fixed to the concave tool, it is placed on the convex tool and the two rubbed together. If now the surfaces are examined, the parts not true will be shown by a brightness which is carefully corrected by the scraper [**10**], until, when the tools are nearly true, a little emery is introduced between the two tools, and by means of a circular swinging motion, continually varied in extent and direction, the two fit each other perfectly. Occasionally, it is necessary to reverse the position of the tools—but always keeping in mind the object of the grinding—to obtain a true spherical figure, and to fit the tools exactly to each other.

Although brass has been recommended as the material for making tools, some workers prefer glass, the chief advantage being that emery does not embed itself in the surface. Amateurs of an inventive turn of mind will have no difficulty in devising other means of shaping the grinding tools. Passable moulds can be made in plaster of Paris by means of the gauges, and type-metal is sufficiently hard for a home-made casting in a plaster mould.

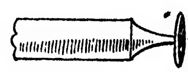
Preparing the Glass. For making an achromatic lens, two discs of glass are needed, one of flint and the other of crown glass. These are sold in pairs, or can be cut out of plate glass (flint for the convex lens) and crown glass (for the concave lens) by means of a revolving iron hoop supplied with sharp sand and water. A pair of "shankers," a tool similar to scissors, and a tool known as a "flonk," made from a piece of a rasp, are also used for chipping or nibbling the glass into shape. The molten glass is sometimes pressed into the approximate shape to minimise work at this stage. The back of the piece of glass is then heaped up with pitch, and the glass cemented to a wooden handle [**11**].



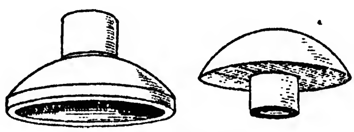
7. LATHE ATTACHMENT FOR LENS GRINDING



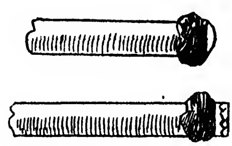
8. BRASS TEMPLATES



10 SCRAPER



9. SPHERICAL GRINDING TOOLS



11. LENS MOUNTED ON HANDLE

Roughing. The next process is called "roughing" or "curving." In this, the lens is approximately shaped by means of a grindstone, emery wheel, or revolving spindle, to which is attached a hardened steel tool, moistened with turpentine. Another method, in which sharp wet sand is allowed to drip on the revolving "shell," against which the glass is pressed, is shown in **12**. The shell is placed in the shallow tray to catch loose sand that flies off during the process. Each side of the glass is roughed, the glass being detached by warming the pitch cement. The parallelism of the two sides is obtained by observing the edge of the glass and the depth of the surfaces by the caliper and step gauges.

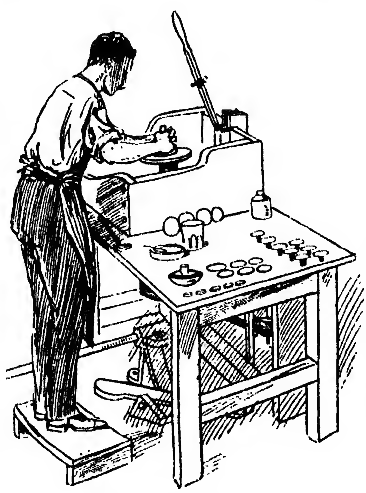
Lens Grinding. The lenses are now ready for grinding in the brass tools. In this operation the lenses are either treated singly or many at a time, according to the size and quality of the work. The lenses are fastened to the tool by means of pitch cement, the process being known as *blocking*. To avoid rounding the edges of each lens it is customary to fill up the spaces between the glass discs with smaller pieces or rings of glass, a certain symmetrical arrangement being preserved to ensure even grinding. Lumps of pitch are placed on the back of each disc, and the glasses pressed into position by means of the cast-iron runner heated sufficiently to melt the pitch. The spaces will now be filled up level with pitch to the surfaces of the lens. The process of grinding now begins. Emery moistened with water is placed on the glass and the tool is worked upon it with a circular swinging stroke, the worker meantime gradually moving round the disc and also turning the tool around. From time to time the tool must be tried with its companion to see that it is not losing figure. From three to six grades of emery are used in the grinding process, from coarsest to finest. Between each grade the lenses are carefully cleaned and care taken that there is no contamination with coarser emery. By examining the surface of the lenses with a magnifier, the operator can judge of the progress of the grinding and detect any scratches. The wetted emery is spread by means of a tool called a "bruiser," a piece of plate glass shaped to the radius of the tool. Excess of emery is wiped off the edges with a sponge. Very little emery is used. When the use of the finest emery is reached, and the lens is true to form, a uniform granular appearance will be presented by the glass. Carborundum, a product of the electric furnace, is coming into use as an abrasive in lens grinding.

Polishing. The next operation is polishing the lens face—that is, converting the milky appearance into a bright, transparent, structureless surface. The polisher is prepared by taking the iron shell made for the purpose, warming it, and coating ⅛ in. thick with pitch cement, pressing the pitch to correct form by the corresponding tool. The surface is now warmed till soft, covered with a piece of broadcloth cut to proper size, which is pressed into place by the counter grinding tool. The cloth adheres and takes the form of the softened pitch. Allow the polisher to get cold, then work into it putty powder to fill up the pores of the cloth and leave a firm, glazed surface. Now, on sprinkling a little water on the surface, the polisher is ready for use. It takes about two hours to polish a lens. In place of broadcloth, silk or other fabric or paper is used for special purposes, and iron oxide may take the place of putty powder. Hand polishing is illustrated in **13**. During polishing the pressure should be very moderate, or the lenses may sink into the surface of the polishing tool and become rounded at the edges. Stress is laid on getting the polisher to begin polishing in the centre of the tool and gradually extending the polish to the edge. A lens that begins to polish at the edges is generally slightly flattened—not truly spherical.

12. ROUGHING LENSES

It will be understood that unless the other side of the lens is to be left plane that the processes above enumerated, grinding and polishing, must be repeated on the second side. The concave lens needed for an achromat is prepared in the same manner, except that the grinding surface is now convex. The convex tool, it should be noted, is always the lower one when several glasses are operated upon together.

Balsaming. The convex and concave lenses are now cemented together. The surfaces fit each other if the lenses have been ground to the same curves. They are freed from all traces of pitch by means of turpentine, and when quite clean are warmed on a "hot-plate." A drop or two of Canada balsam is let fall into the concave lens and the convex lens pressed upon it until all air bubbles are expelled. The lens is left on the hot-plate to bake for an hour, and allowed to cool, when the balsam will have become hard.



13. POLISHING LENSES

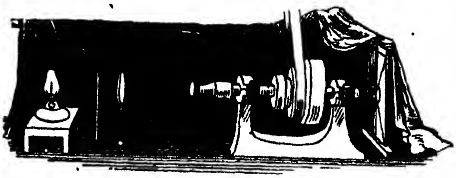
Testing. The method of testing lenses to see that their optical and geometrical centres correspond is shown in **14**. The lens is cemented to a chuck upon one end of a hollow lathe mandrel. Near the opposite end there is a ground-glass surface and in front of the lens a large standard lens. Beyond this is a small vertical rod and lamp. These pieces of apparatus are all in line with the axis of the mandrel, and an image of the rod is cast upon the ground-glass screen. If the image remains stationary while the lathe revolves, the optical centre of the lens corresponds with the centre of rotation. If this is not so, the cement with which the lens is attached is warmed sufficiently to allow the lens to be moved to the correct position. The edges of the lens are finally trimmed to the correct form by holding a brass or iron surface charged with emery or sand against the rapidly revolving lens. The curvatures of the surfaces of high-class lenses are tested by what are known as *contact gauges*. These are pieces of very hard glass the exact counterpart of the surface to be tested. When the two surfaces are placed together and reviewed by reflected light, rainbow or interference colours are shown when the surfaces are exceedingly close together.

Lens Mounting. For mounting or setting lenses for various optical purposes the machines used in other branches of light engineering work are required, such as lathes, milling machines, drilling machines, and presses. The lightness or heaviness of the design will depend upon whether the instrument is for commercial use or for delicate work that can be done only by a skilled operator. It is obvious that in instruments requiring absolute rigidity the construction should not be too flimsy, but, on the other hand, excessive heaviness is an indication of bad design. Fantastic curves should be avoided, and the adjustments made as simple as possible.

The tubes or cells in which lenses are mounted for telescopes, microscopes, and photographic lenses are formed from sheet brass, although some of the newer alloys in which aluminium forms a constituent are coming into use with advantage as regards lightness and incorrodibility. The sheet brass of the necessary size to form the required tube has its edges straightened and brightened by filing. The piece of brass is then rounded upon wood by means of a mallet till the edges are in contact. The edges are then joined by spelter soldering over a coke fire. The tube is then pickled in weak sulphuric acid and sand-scoured. Next it is submitted to a drawing process, by which it is elongated, stiffened, and brightened, the finishing being done on a brass-

turner's lathe with a series of special tools. The brass surfaces which are on the outside of an instrument are lacquered, while internal parts are blacked with either a chemical colouring or a mixture of vegetable black and gold size.

The iris diaphragms fitted to photographic lenses and microscopes are made of eight to sixteen thin semicircular segments of hard-rolled brass. The older pattern of diaphragm—a piece of metal with a hole in the centre—requires no explanation, but it should be noted that the rapidity of the lens depends on the aperture or size of the diaphragm. The size of the diaphragm is calculated as a fraction of the focal length. For example, a diaphragm marked *f*4 means that its diameter is one-fourth of the focal length of the lens, and all lenses having an aperture one-fourth of their focus are assumed to be of equal rapidity. The Royal Photographic Society of Great Britain have standardised a series of apertures as being those most generally useful.

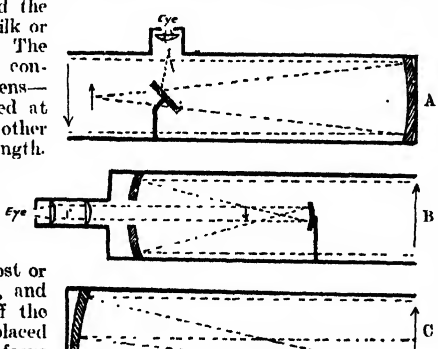


14. TESTING LENSES

Telescopes. There are two classes of telescopes, *refracting* and *reflecting*. The refracting telescopes depend on a system of lenses, the object glass forming the image and the eye-piece magnifying it, while in the reflecting telescopes the rays are reflected on to a speculum or polished mirror, inverted images being formed in both cases in the focus of the lens or mirror.

175.

Refracting Telescopes. These are the oldest form of telescope. In the simplest character they consist of an object glass of one lens and an eye-piece of one lens, but of shorter focus. The best lenses for telescopes are ground and polished by hand. The lens, if small, is held by cement to a handle, and the polishing is done upon silk or with the pitch polisher. The eye-piece of a telescope consists of a compound lens—that is, two lenses placed at a distance from each other equal to half their focal length. The two lenses are usually plano-convex, with the convex faces towards the object glass. The larger lens, called the *field-glass,* is innermost or nearest the object glass, and a diaphragm cutting off the marginal rays is usually placed between them near the focus of the eye-lens, where the image is formed. This eye-piece is generally called the *negative* eye-piece. The Ramsden, or *positive*, eye-piece has the lenses of nearly the same focal length, but the distance from each other is less than the focal distance of the lens nearest the eye. The focusing of the telescope is effected by a rack and pinion motion acting on the tube which carries the eye-piece.



15. REFLECTING TELESCOPES
A. Newtonian B. Gregorian C. Herschellian

Reflecting Telescopes. The advantage of this form of telescope is the great quantity of light which it collects. Faint nebulæ and stars, which are invisible to the observer with a refracting telescope, can be detected by this type of telescope. The three forms of reflecting telescopes are seen in 15. There are, however, many variations. In the Newtonian telescope the real image is formed by a concave mirror, and the reflected rays turned aside through 90° by a plane reflecting surface. The magnifying eye-piece is at the side of the instrument. In the Gregorian form the reflected rays are sent back along the axis of the instrument. These rays, or the central portion, are allowed to pass through a small central hole in the concave mirror, and examined by the eye-piece on the other side of the mirror. The eye-piece is at the end. The Herschellian telescope has the concave mirror tilted slightly to one side. It will, without loss of light, due to the intervention of a second mirror, bring the real image towards one side of the tube, where it is examined by an eye-piece directed obliquely towards the mirror.

Speculum Grinding. The difficulty in making the specula or mirrors for reflecting telescopes is to get a perfect image, owing to the defect of spherical aberration. On this account the polishing is directed towards attaining a parabolic form. Many of the operations of grinding resemble those described in lens making.

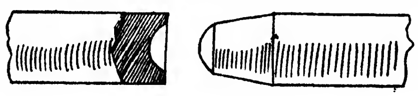
The Microscope. Microscopes are classed as *simple* and *compound*. To the former class belong the lens or combination of lenses such as the reading glass or pocket magnifier. The lenses are of the double convex type. A Coddington lens is such a lens, with a groove cut all round and filled in with black varnish so as to form a diaphragm. The Stanhope lens is similar, except that the two sides of the convex lens are unequally curved. The side with the most convexity is placed next to the eye. Aplanatic magnifiers consist of a convex lens with a thin concave lens on each side, by which means colour is corrected and a flat field obtained up to the margin.

The Compound Microscope. This is a combination of lenses arranged so that the image formed by the objective lens is magnified by the eye piece, or ocular. The parts of a microscope, in addition to the lenses just enumerated, will now be given. Firstly, the foot, or base; this in English microscopes is the tripod or pillar form. The horseshoe form is always made on the Continent, and has advantages when the microscope is used other than in a vertical position. The *stage,* that portion just beneath the objective, is provided with springs to hold the slide in position. It is made of brass and may be faced with vulcanite. The aperture should be sufficiently large to admit the finger. A refinement of the stage is the *mechanical stage,* which is provided with arrangements for giving rectilinear movements horizontally and vertically. The stage is also sometimes graduated so that the position of the slide can be noted for future guidance. For some purposes a *rotary stage* is provided, by which means an object can be rotated to coincide accurately with the optic axis of the microscope.

The *mirror* is carried on a square or circular tail-rod, and is designed to reflect light on the object. The mirror generally has two faces—one plane and the other concave. The sub-stage beneath the stage carries the condenser, which concentrates and focuses the light of the object. The sub-stage is provided with a focusing arrangement. The *diaphragm* is a means of moderating the light, so that it shall bear some ratio to the apertures of the various objectives.

The *limb*, or *pillar*, is the arm carrying the *body tube*, into the lower end of which the objective is screwed. The limb carries the *coarse* and *fine adjustments*—rack and pinion methods of attaining an accurate focus. The size of the body tube varies from 0·9173 in. to 1·41 in. The length of the English tube is 10 in., the Continental tube 6 in. to 7 in. The objectives are specially corrected for the various size tubes. The body tube is made with a *draw-tube* to enable the smaller tubes to be extended. *Binocular microscopes* have two eye-pieces, so that both eyes can be used at the microscope, a prism being used for uniting the images.

Microscope Lenses. These, being so small, have to be made singly. The piece of glass is cemented on the end of a stick, and the roughing is done on a grindstone. The templates are small discs of steel turned in the lathe. The brass "cups," or tools, are charged with emery, and rapidly revolved on the lathe, the lens being formed by holding it against the surface. These tools are shown in **16**.



16. TOOLS FOR GRINDING MICROSCOPE LENSES

The polishing is usually done with crocus mixed with beeswax. The lenses are stuck to the handle by means of shellac. The terms 1 in., ½ in., etc., used to designate the focal power of objectives, represent the approximate initial magnifying powers without eye-piece at a distance of 10 in. from the back lens. As the relative size of object and image vary directly as their distance from the centre of the lens, it follows that the less the equivalent focal distance the greater is the size of the real image. Dry objectives are those which have air between the objective and cover glass. Immersion objectives have a liquid in place of air. This liquid may be water or cedar-wood oil. The adoption of Jena glass has brought forth a new series of microscopes in which many of the aberrations of older forms are quite overcome.

The Oculars or Eye-pieces. The eye-piece most frequently used is the Huyghenian, or negative, eye-piece. It consists of two plano-convex lenses, both with their plane surfaces next the eye. The one nearest the eye is always half the focal length of the other, and the distance between the two lenses must be half the sum of their combined foci. The Ramsden, or positive, eye-piece consists of two plano-convex lenses. The convex surfaces are placed towards each other, the foci of both being the same and the distance of the lenses from each other two-thirds the focal distance of one lens. The Kellner eye-piece consists of a bi-convex field lens, and an achromatic doublet meniscus for the eye lens. Compensating eye-pieces are specially constructed for use with apochromatic objectives, certain corrections being rectified by the eye-piece, which, for optical reasons, were left undone in the objective. The magnification of eye-pieces ranges from 4 to 15, 5 to 6 being about the lowest that can be satisfactorily used on the short tube-length for which achromatic lenses are corrected. A *projection eye-piece* is one used for projecting the image formed by the objective on to a screen for demonstration purposes.

R.M.S. Standards. The Royal Microscopical Society of London in 1857 introduced uniformity in screws for microscopic objectives. The specifications of this standard are as follows: Whitworth thread—Pitch of screw, 36 to 1 in.; length of thread on object glass, 0·125 in.; plain fitting above thread of object glass, 0·15 in. long, to be about the size of the bottom of male thread; length of thread of nose-piece not less than 0·125 in.; diameter of the object-glass screws at the bottom of the screw, 0·7626 in.; diameter of the nose-piece screw at the bottom of the thread, 0·8 in. The Society supplied gauges and a master tap, or "bob," for cutting screw tools, but as the mechanical difficulties in the making of these taps were considerable, there grew up differences in the Society screws. In 1896 the Society again considered the question, and devised a method by which it can be kept to the standard. The new screw is almost exactly the same as the original standard.

The diameter of the draw-tubes of microscopes has also been standardised by the Royal Microscopical Society as follows:

No. 1, 0·9173 in., 23·3 millimetres.
No. 2, 1·04 in., 26·416 millimetres.
No. 3, 1·27 in., 32·258 millimetres.
No. 4, 1·41 in., 35·814 millimetres.

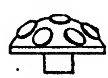
No. 1 is the size in general use on the Continent and in England for students' microscopes; No. 2 is the mean of the sizes in use by English makers; No. 3 is the new size used for the larger English instruments, especially binoculars. No. 4 is used in few English microscopes.

Photographic Lenses. The simplest lens used in photography is known as the *spectacle lens*. As it is non-achromatic, it possesses the defect of chromatic aberration. When used for photographic purposes, a correction has to be made after focusing, as the chemical focus (that observed by the photographic plate) is shorter—that is, lies nearer the lens than the visual focus. The correction is one-fortieth of the focus of the lens. Such lenses are now used only in hand-cameras of fixed focus. The method of correcting colour defect has been dealt with in the manufacture of lenses. These achromatic lenses are excellent for landscape photography, but are not suitable for architectural subjects, owing to the distortion of the marginal lines. This defect is got over by placing between two single lenses a stop, or diaphragm, forming a "rapid aplanat" lens, also known as *rapid rectilinear* or *symmetrical* lens. The lens includes an angle on a certain sized plate which may vary from 45° to 90°; if between 80° and 90° the lens is known as a wide-angle lens. The component parts of the rapid rectilinear lens can obviously be used separately with certain limitations. The "portrait" lens has a front and back combination, the curves of which have been specially calculated to give freedom from spherical aberration and great rapidity. The area of sharpness is, however, restricted. Astigmats are a class of lens rendered possible by the introduction of new kinds of glass. With crown and flint glass achromatism could be corrected, but some of the kinds of spherical aberration (Von Seidel specifies five kinds), astigmatism and coma (defects which occur towards the margin), and curvature of field (the lens gives saucer-shaped or convex fields) could not be attacked. Miethe's astigmat and

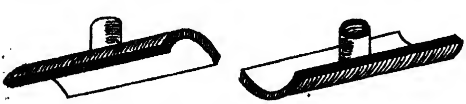
Schroeder's concentric lenses were the first in which the new Jena glasses were used. These were introduced in 1888, but have since been superseded by more modern anastigmats, such as Goerz's double anastigmat, computed by Von Hoegh, in which there are ten lenses and at least four different kinds of glass. Other similar lenses are the Zeiss convertible anastigmat, calculated by Rudolph, Voigtländer's collinear lens, Steinheil's orthostigmat, and Busch's aplanat. An English lens—the Cooke—has only three lenses, but perfect correction of the above named defects has been attained. The Grün lens, which works exceedingly rapidly, is constructed to hold a reservoir of cedar oil between the front and back combination. It is used for photographing in theatres. The telephotographic lens of Dallmeyer is designed for obtaining large images of distant objects. It may be regarded as a combination of a telescope with a photographic lens. The photographic component is placed in front, and takes the form of a "stigmatic" lens.

Lens Adjustment. The adjustment of the various lenses in their cells is a matter of great delicacy. The lenses are first mounted in a trial mount so as to permit of an approximation of the separation of the lenses. The performance of the lens is tested on a watch dial or other similar test object and the exact amount of separation determined and marked for the final adjustment. A deviation of a small fraction of an inch is sufficient to affect the performance of a lens, hence it will be seen that time spent in the adjustment is well spent. Standard lens flanges have been devised by the Royal Photographic Society, but have not been favourably received.

Spectacle Manufacture. In making the lenses used for spectacles a large number of pieces of glass are cemented to the tool [17]. Emery is used for grinding, and a slow rotatory movement is given to the upper tool by machinery. The tool when charged is known as a *form*, and a "bench" of forms is usually attended by one man. The spectacle-maker often grinds special curvatures by hand. The finished discs are cut to shape by shankers or a diamond-cutting machine constructed to yield elliptical figures. The edges of the lenses are ground smooth and to the shape of the frames by revolving emery wheels or grindstones, the lens being held between the finger and thumb. For rimless glasses a polish is imparted to the edges, while grooved edges for "invisible" frames are obtained by revolving angular-edged metal wheels. The tools used in manufacturing cylindrical glasses are shown in **18**; the motion given to them by the machine is backwards and forwards.



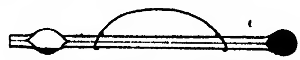
17. SPECTACLE LENS GRINDING



18. CYLINDRICAL GRINDING TOOLS

Thermometers. The temperature or hotness of a body is measured by an instrument called a *thermometer*—a glass tube with a bulb on one end partially filled with mercury or alcohol. Alcohol is used because it cannot be solidified, except at a very low temperature, and mercury because it boils only at a moderately high temperature. The mercury thermometer is most extensively used. A piece of glass tubing of fine bore (capillary) is taken, and by means of heat a bulb is formed on one end; the tube is then filled with mercury by dipping the open end into mercury, the end is sealed, and the tube is graduated to show the various temperatures.

Manufacture of Thermometers. The thin glass tubing selected must be of a narrow and uniform bore. This can be ascertained by measuring a short column of mercury at different points of the tube. A bulb, which may be spherical, pear shaped, oval, cylindrical, or tubular, is then blown by strongly heating one end of the tube, and, having fixed an elastic ball to the other end, blowing in sufficient air to give the necessary expansion to the softened glass. The elongated form is to be preferred, as it offers a large surface to the action of the air. The end bulb having been blown, a second is added a short distance from the other end, and when this has half cooled, the open end is dipped into pure, recently distilled mercury, which gradually rises into the tube. In this way the lower bulb is gradually filled. The tube is next held by a wire, as shown in **19**, and heated over a furnace until all the air has been expelled by the boiling mercury. While the mercury is still hot, the open end of the tube is touched with sealing-wax. When quite cool, the mercury fills the lower tube and bulb. The tube is then inclined, and the lower bulb heated to a temperature higher than the thermometer is intended to indicate. Some of the mercury is thus expelled, and as the mercury begins to retreat on cooling, the tube is hermetically sealed just below the upper bulb, which is pulled away. The filled tube is then stored for some time or heated for several days to 50° or 100° above the temperature it is intended to indicate, so as to season the glass.



19. THERMOMETER MAKING

Graduating the Thermometer. The tube is next divided into a number of graduations depending upon the scale selected. The Fahrenheit scale is the oldest, and dates from 1724. It is used in Great Britain and the United States. This scale was primarily divided into 180°: zero was placed at temperate: the point to which the liquid rose when placed under the arm of a healthy man was marked 90°: and the temperature of a mixture of ice and salt, then believed to be the greatest possible cold, was marked 90°. The scale was subsequently altered as follows: 0° was the coldest temperature, and the space between this point and that representing the warmth of the human body was divided into twenty-four degrees. The freezing point of water was then 8°, but as these long degrees were inconvenient, each was divided into four, and 8° became 32°; blood heat, 96°. A mercurial thermometer thus graduated registered 212° as the boiling point of water. In 1730, Réaumur made alcohol thermometers with their zero at the freezing point of water, and the boiling point of water at 80°. The corresponding mercury thermometers were subsequently introduced, and are still used in some parts of the Continent. A centesimal scale was adopted by Celsius in 1742; the boiling point was marked 0°, and the freezing point of water 100°. The points were subsequently reversed by Linnæus, and the scale is now known as *Centigrade*. Such a scale is used for scientific purposes and in many Continental countries. A comparison of the Fahrenheit and Centigrade scales is given on page 1565.

The Freezing Point. Of the two fixed points needed on a thermometer the freezing point is first marked. The whole of the thermometer tube is placed vertically in a vessel of snow or melting ice. After about half an hour, the tube may be raised till the top of the mercury can be seen, which is marked with a file. Thermometers for use in very cold countries have a still lower point indicated, that of the freezing point of mercury. This temperature is obtained by mixing solid carbon dioxide and ether.

The Boiling Point. This is the temperature of water boiling at normal pressure (760 mm.). To determine this, either Regnault's apparatus or a long, narrow-necked flask is used. The former, which is preferable, consists of a cylindrical copper vessel with double sides, between which the vapour of water circulates, there being no possibility of the exterior air reaching the thermometer. To ensure the regular escape of steam, a small manometer communicates with the interior of the boiler, to indicate the least pressure within. The whole of the mercurial column must be exposed to the vapour of the rapidly boiling water, but, after a few minutes, it may be raised just above the cork, and its position noted. As the boiling point of water depends upon the pressure of the atmosphere, the height of the barometer must be taken. If it stands at 760 mm., the temperature is 100° C.; if not, a calculation will be necessary—1° C. or 1·71° F. must be added or subtracted for every 26·7 mm. above or below 760 mm. The interval between the two fixed points is then divided mechanically into the requisite degrees, according to the scale chosen.

Verification. For common use, extreme accuracy is not called for in a thermometer, but if needed for accurate scientific work, the scale readings need checking. The method is by comparison with a thermometer of known accuracy. The freezing and boiling points of both thermometers should correspond, the readings being accurately determined through a lens. The standard thermometers are made at the Kew Observatory of the Royal Society, where elaborate precautions are taken in the selection and seasoning of the glass and graduation of the tube. The limits enforced at Kew for thermometers are that all thermometers are rejected when the largest error at any point is greater than 0·3° F., or when a space of 10° F. is more than 0·3° F. wrong.

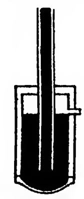
Various Thermometers. Instruments for measuring extremes of temperature are known as maximum and minimum thermometers [see page 1565]. The former is provided with a constriction just above the bulb, so that, although the mercury passes out easily, it cannot recede past the constriction. In other forms, a minute air bubble is left or a plug of porcelain is inserted just above the bulb. The expanding mercury passes the porcelain, but when once past, cannot return. Minimum thermometers are usually spirit thermometers with an index in the stem. If the spirit contracts in consequence of a fall of temperature, it carries the index towards the bulb, but when, subsequently, a rise of temperature occurs, the spirit flows past the index, the latter being left in position to register the lowest temperature. These two thermometers can be combined as a maximum and minimum thermometer. One form consists of a U-tube with a bulb at each extremity: each arm of the tube is half filled with mercury; one bulb and the remaining portion of the tube above the mercury is filled completely with alcohol: the other bulb is only partially filled with this liquid. A steel index, prevented from falling by a hair tied round it, moves on the surface of the mercury in the side tubes. Should a rise of temperature take place, the spirit in the full bulb expands, causing the mercury to push up the index in the other limb. The reverse occurs when a diminution of temperature takes place. The lower ends of the indices nearest the mercury indicate the maximum and minimum temperatures. Clinical thermometers are modified forms of the maximum thermometer with constriction above the bulb. An open scale is obtained by making the bore of the tube very narrow, and the optical properties of the convex edge of the glass are utilised for the purpose of obtaining a magnified image of the exceedingly fine thread of mercury. The range of temperature given in clinical thermometers is from 90° F. and 110° F., so that the length of the instrument is small. The sensitiveness of the thermometer is assured by making the bulb of special shape, but care must be taken that the glass is not so thin as to be elastic to pressure. Thermographs are self-registering thermometers. They consist of a curved metallic tube filled with spirit and hermetically sealed. The tube is firmly fixed at one end, and as changes of temperature alter its curvature, they cause the free end, which is connected to a pen by multiplying levers, to move. Fire alarm thermometers are also made. In this form a thermometer is balanced on a knife-edge, a sliding band having previously been placed at the temperature which has not to be exceeded. When this temperature is reached, the mercury overbalances the thermometer, and causes its upper end to make contact with the wires of a battery; a bell immediate rings to give the alarm. Instruments for measuring very high temperatures are known as *pyrometers*. These depend on the expansion of a rod of metal or other solid substance, the difference in expansion of two solid substances, or the coiling or uncoiling of a spiral composed of two or more metals rolled or welded together to form a ribbon.

Barometers. An instrument for measuring the atmospheric pressure is called a *barometer* [see page 1139], the most usual kind being that in which variations in the height of a column of mercury in a tube are noted. If a glass tube a yard long and a quarter of an inch diameter is sealed at one end and filled with mercury and then inverted in a vessel of the same metal, the mercury in the tube sinks until it is about 30 in. above the surface of the liquid in the reservoir. This is known as Torricelli's experiment [see page 1139], and the observation that the variation of the height of the mercury depends on the pressure of the atmosphere suggested the use of this fact for measuring and recording the changes in pressure. Pascal repeated Torricelli's experiment with water, the tube in this case being 50 ft. long. The atmosphere was found to support a height of 34 ft. of water, which corresponds to the height of the mercury when the difference between the weight of the two liquids is taken into account. Water barometers have been constructed and found extremely accurate, but the disadvantages of such a long tube of water and its liability to damage by frost have prevented its use except as a curiosity.

Types of Barometers. The main types are *mercury* barometers and *aneroid* barometers. Of mercury barometers the chief kinds are (1) the siphon; (2) the Fortin or cistern barometer [**20**]; and (3) the Kew pattern. In addition to these instruments intended for accurate observations there are the weather-glasses as originally suggested by Admiral Fitzroy, which are usually called *wheel barometers* [see page 1140]. The aneroid barometer

does not require the use of mercury. The variations of the atmospheric pressure act on a metal box which has been deprived of air and are communicated to a scale. We shall first deal with the construction of the mercury barometer.

How to Make a Barometer. First of all a piece of tubing 42 in. long is taken: it should be of ¼ in. bore or even slightly larger, and it is better not to use lead-glass tube as the mercury in time acts on the glass and dims the interior. The tube is well cleaned first with sulphuric acid and water, then with several rinsings of water, and finally with alcohol. It is put to dry and carefully protected from dust. One end of the tube is closed by heating it in a Bunsen flame, care being taken to get a nicely rounded finish to the end of the tube. The edges of the open end should be rounded off by carefully heating in the flame. The next step is to make a U-shaped bend 36 in. from the sealed end. The glass must be heated gradually so that the diameter of the tube remains the same throughout the bend. This will leave a short limb of about 3 in. and a long tube of 36 in. The U-shaped bend should not be quite parallel; it is better to make a slight inclination, as this facilitates the introduction of the mercury at the subsequent stage.



20. BAROMETER CISTERN

Reference to page 1139 will show the form of the tube, which is, after bending, fastened on the support, a piece of hard wood 38 in. long, 3½ in. wide, and at least ⅝ in. thick. Various items, such as means for hanging up the board, will suggest themselves to the worker, and there is no objection to bevelling the stand and rounding off the corners. The space where the mercury tube is to lie is hollowed out, and when it fits nicely in its place the tube is fastened there by brass clips. Along the tube is placed a sliding scale, which next needs to be considered. This is best made of cherry-wood or mahogany and is 32 in. long, while in the upper and lower part slits are cut and through these brass screws with milled heads are inserted, the object being to allow of sliding the scale upwards and downwards in a certain constricted sphere. The scale, which is usually of ivory or one of its substitutes, is fastened near the top of the sliding scale just described. It is 4 in. long and divided into inches and tenths, the lowest inch mark being 29, the next 30, and the upper one 31. The scale is placed so that the 30 in. mark is exactly 30 in. from the bottom of the slide, which is furnished with a brass edge, the purpose of which is to make easier the adjustments required when the barometer is read.

Filling the Barometer Tube. The next step is to introduce the mercury, which should have previously been purified by being squeezed through chamois leather. The tube is laid on its side with the short limb uppermost. The mercury is put into a glass flask and boiled to expel moisture and air: then, when still hot, poured little by little into the short limb of the tube through a glass funnel with L-shaped tube. By manipulating the tube the air in the tube is partly dislodged, and this is completed by corking the open end and passing the tube gradually through a flame so as to boil the mercury from end to end. The result is a perfectly bright tube of mercury free from air. The mercury is allowed to cool and the tube raised to the vertical position—the closed end uppermost. The mercury will sink a little as in the Torricellian experiment, the excess of mercury running out of the short limb. Enough mercury is expelled from the short limb, by inserting the finger or a wooden plug, to leave 2 in. empty. The bottom of the sliding scale is brought opposite to the top of the mercury in the short limb, and the height of the column—the atmospheric pressure—is shown on the scale at the other end. A cover is fitted on the open end of the mercury.

Wheel Barometers. Another variety of the siphon barometer is especially intended to indicate good or bad weather. This is managed by means of a float on the top of the mercury in the short limb. A string attached to this float passes round a pulley and at the other end there is a weight somewhat lighter than the float. A needle fixed to the pulley moves round a graduated circle on which is marked "stormy," "rain," etc. Admiral Fitzroy, who wrote a much used treatise on the weather gives the following as the indications. When the mercury stands at:

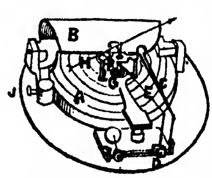
31 in.	it indicates	very dry	weather
30·5	,,	settled fair	,,
30	,,	fair	,,
29·5	,,	changeable	,,
29	,,	rain	,,
28·5	,,	much rain	,,
28	,,	stormy	,,

The following directions are also usually given on one of this type of barometer; they were originally drawn up by Admiral Fitzroy:

Rise for North NW—N—E Dry or less Wind	Fall for South SE—S—W Wet or more Wind
Except Wet from North	Except Wet from North
Long foretold, long last; Short notice, soon past.	First rise after low Foretells stronger blow.

It must be confessed, however, that the indications of the wheel barometer are only approximate, as the height of the mercury depends on the height of the place where the barometer is above the sea-level. The weather also depends on other circumstances than atmospheric pressure. A thermometer is usually fitted on the case of a barometer.

Aneroid Barometers. The principle of the aneroid barometer has been explained on page 1139. The illustration [21] will be described in detail as it serves to explain the exact working of an aneroid. The outer case and the face of the instrument are removed, but the hand is attached by its collet to the arbor. A is the corrugated box which has been exhausted of air through the tube J, and hermetically sealed by soldering. B is a curved spring resting in gudgeons fixed on the frame-plate and attached to a socket behind F, in the top of the box. A lever, C, joined to the stout edge of the spring is connected by the bent lever at D with the chain E, the other end of which is coiled round and



21. ANEROID BAROMETER

fastened to the arbor F. As the box A is compressed by the weight of the atmosphere increasing, the spring B is tightened, the lever C depressed, and the chain E uncoiled from F, which is thereby turned so that the hand H moves to the right. In the meantime the spiral spring G, coiled round F and fixed at one extremity to the framework and by the other to F, is compressed. When, therefore, the pressure decreases, A and B relax by virtue of their elasticity; E slackens, G unwinds, turning F, which carries H to the left. Near J is shown an iron pillar cast as part of the stock of the spring B. A screw works in this pillar through the bottom of the plate by means of which the spring B may be adjusted to the box A so as to set the hand H to read on the scale according to the indications of a mercurial barometer.

Barographs. These are self-registering barometers. The principle of registration is either (1) photographic; (2) mechanical; (3) electrical; or (4) by balance. The photographic method consists in moving a strip of sensitive paper at a given rate behind the top of the mercury column of a barometer. The mechanical method is by means of a float as in the wheel barometer, the motions being communicated to a pen passing over a revolving drum of ruled paper. The electrical method has one pole of a battery in contact with the mercury in a siphon barometer, and at fixed intervals of time the platinum contact point at the other pole of the battery is made to descend the open limb of the barometer until it comes into contact with the exposed mercury or a metallic float, when the circuit will be closed. The current caused by this closing of the circuit can be utilised in several ways to record the height of the mercury column. The balance method works by gravity and is known as the *steelyard barograph.* The balance arm resting on the mercury is counterpoised, the differences or movements being recorded. These are for accurate determinations, but the barographs working on the aneroid principle are the most popular and are accurate if precautions are taken occasionally to check the records by a mercury barometer. The instruments have from two to six exhausted boxes coupled up, and the combined motion of the vacuum boxes is communicated to a recording pen by means of multiplying levers.

Chemical Weather-glass. The chemical weather-glass or camphor barometer is a tube of a chemical solution which thickens or clears up according to the variations in the weather conditions. Glass tubes 10 in. long and $\frac{3}{4}$ in. diameter are nearly filled with the following liquid: camphor, 2 dr.; potassium nitrate, $\frac{1}{2}$ dr.; ammonium chloride, $\frac{1}{2}$ dr.; dissolved in absolute alcohol 2 oz., water 2 oz. The contents of the tube must be uniform when filled. The tube is fastened to a flat piece of wood in the same manner as a thermometer. This weather-glass should be exposed to the north, shaded from the sun. A good deal of the changes which take place in the liquid depend on the temperature, but that is not the only factor in affecting the chemical solution. The changes of the solution signify the following:

Clear liquid, bright weather.

Crystals at bottom, thick air, frost in winter.

Dim liquid, rain.

Dim liquid with small stars, thunderstorms.

Large flakes, heavy air, overcast sky, snow in winter.

Threads in upper portion of liquid, windy weather.

Small dots, damp weather, fog.

Rising flakes which remain high, wind in upper air regions.

Small stars, in winter on bright, sunny days, snow in one or two days.

Another form of chemical barometer consists of a figure wearing a dress saturated with a solution of cobalt chloride. In damp weather the dress changes to a pink; in fine, dry weather to a blue. A piece of catgut on tension is also very sensitive to changes of moisture and this fact is taken advantage of in the weather indicator which consists of two little figures. One of the figures carries an umbrella, and, when the catgut is affected in a certain direction, this figure comes out of an aperture and indicates wet weather. When the catgut is twisted in the opposite direction a figure in summer attire appears from another aperture. The familiar changes in the feel of a piece of seaweed which is popularly used as a weather guide depends on the quantity of salt in the tissues of the seaweed.

Measurement of Atmospheric Motion. The direction of the wind is indicated by a wind vane or common weathercock, while the effect of the wind is shown by anemometers, the pressure suction or power of rotation being made apparent. Of the various types of anemometer the most frequently used is that known as the Robinson, one pattern being shown in 22. Four hemispherical cups are mounted at the ends of two crossed arms supported horizontally on a spindle. When exposed to the wind the unequal pressure on the convex and concave surfaces of the cups causes the arms to rotate, and the number of revolutions is recorded by a simple counting apparatus. The dial is graduated to show the number of feet or miles of air which has passed. The diameter of the cups is from 4 in. to 9 in. and the spindle rotates on ball bearings. Another type depends on the suction which the air produces as it blows past an orifice, or the pressure which it exerts when blowing into a tubular opening which is turned by a vane so as to be always facing the wind. These instruments are also made self-recording.

22 ROBINSON ANEMOMETER

Measurement of Aqueous Vapour. Absolute moisture in the air is measured by chemical means, or by determining the temperature of saturation known as the dew point. The instrument is called a *hygrometer.* The wet bulb thermometer gives a rough indication of the humidity or dryness of the air. The measurement of the rain is done in a rain gauge or pluviometer. To measure the fall of snow it is usual to reckon that a foot of snow equals an inch of rain. Recording rain gauges are of two types. In one the rain collects in a bucket which tilts over each time it is filled, the number of tilts being recorded on a revolving drum. The other pattern depends on the employment of a float which as it rises on the water records its motion on a revolving drum. An instrument which automatically records the direction of the wind, velocity of the wind, temperature of the air, pressure of the atmosphere, and rainfall is known as a *meteorograph.*

Group 25 ILL-HEALTH 5 Continued from page 6039	RESPIRATORY ILL-HEALTH

Continued from page 6039

RESPIRATORY ILL-HEALTH

Some Common Diseases of the Respiratory Organs. Their Causes and Symptoms. Nose and Throat Troubles. The Growth of Consumption

By Dr. A. T. SCHOFIELD

THE respiratory organs are peculiarly complicated, delicate, and sensitive in structure and function. Forced to inspire seventeen times a minute whatever air is next the mouth and nose, they are the first to be affected by the endless impurities, poison, and bacteria with which the air swarms; and very many of those respiratory affections that at one time were put down to catching cold are now proved to be due to infectious germs inhaled in ordinary respiration.

Causes of Respiratory Troubles. The climate of these islands, so capricious and variable, has, of course, a great deal to answer for in these diseases.

Then, again, there are the vagaries of fashion to consider. Disturbances, too, of the circulation in the lungs and mucous membrane of the air passage are very common owing to the complex nature of the blood supply to their parts.

The delicate lung tissue itself is peculiarly liable to degenerative changes; the respiratory system as a whole is specially under nervous influence, so that a large number of its diseases are directly or indirectly of nervous origin.

We may now pass on to consider some respiratory diseases in detail. We will begin with the nose, and the first respiratory trouble that may be referred to is not using it for inspiration. Breathing through the nose is a safeguard against many respiratory diseases. It warms, moistens, filters and perfectly purifies the air, so that it cannot injure the delicate lungs; and yet by a strange perversity nearly one-third of the population, perhaps more, cannot habitually inspire through the nose, but take in all the air through the mouth, to the destruction of the teeth, the drying of the tongue, and the swallowing of the disgusting dust with which town air is so often laden, to say nothing of the admission of this raw, dirty fluid direct to the lungs. There are, of course, in some cases obstacles to breathing through the nose, but in most people it is simply a bad habit.

Diseases of the Nose. The most common obstructions nowadays are adenoids, or growths at the back of the nose, reaching from the throat, that obstruct the passage of the air. They are common in school-children, and not only obstruct the breathing, but exercise a prejudicial effect on the mental development, making the child heavy and stupid. They should, therefore, be removed as soon as possible.

Polypi in the nose are softer growths. Both cause the speech to be nasal, and if large may induce deafness. The nose may also be obstructed by a thickened or crooked septum between the two nostrils. This also requires operation. Bleeding from the nose, resulting from congestion and bursting of the small veins, is sometimes violent. It is seldom as dangerous as it looks, and is often a relief to the congested brain.

The nose has a very sensitive mucous membrane and is liable to inflammation not only from catarrhs, of which we shall speak, but from special irritants, as in hay fever or hay asthma. In this the mucous membrane of the nose is specially affected, but the eyes and throat often suffer as well. The general irritant is the pollen of grass and flowers. There is constant sneezing (Nature's effort to get rid of the irritant), running at the nose, cough and sore eyes. The cure consists in stopping all irritation by living in towns or by the sea, and in a little cocaine solution on cotton wool being inserted in the nose. Bad cases require medical advice.

Diseases of the Tongue. In the tongue we have several diseases. Glossitis is a rare inflammation of the tongue, but ulcers of the tongue are common and not very easy to heal. If they are small and not hard round the base they are not dangerous; but if they are hard with a bad discharge a doctor should be seen at once.

Cracked tongue is very common in dyspepsia, and is troublesome to cure, though in all affections of the mouth and tongue it must ever be remembered that the saliva itself has a very healing effect. The mouth itself, apart from the tongue, may be ulcerated, and the same importance attaches here to a hard base and a foul discharge which indicates medical treatment. In children small ulcers are common, caused by not cleansing the mouth after feeding. A white coating to the tongue and mouth called "thrush" is also common from the same cause. The home treatment is to rub the tongue well with glycerine and borax.

Throat Troubles. Sore throats are of great variety. They may arise from indigestion, colds, debility, infection, etc. We get pharyngitis, or inflammation of the back of the throat, in scarlet fever and from colds, and from much speaking; also laryngitis, or inflammation of the larynx, which lies just in front of the gullet and may be acute or chronic. It arises from infection, colds, and over-use of the voice. There is in fever loss of voice, some difficulty in breathing and swallowing, with often a hard, brassy cough. When this occurs in children it is sometimes called false croup. True croup (so-called), with the formation of membrane, is really diphtheria. The danger, of course, in acute laryngitis is suffocation, and for this surgical interference by tracheotomy may be necessary. Chronic laryngitis often

accompanies consumption, and, in these cases, is tubercular in character. The simple form is the result of continual catarrhs or of voice strain. The variety common to public speakers, and very hard to cure, extending up into the pharynx, is called "Clergyman's Sore Throat." Mild laryngitis, acute or chronic, is relieved by inhaling a teaspoonful of Friar's Balsam in half a pint of *boiling* water.

Tonsilitis. Tonsilitis, or quinsy, is a painful affection of the mouth, mainly involving one or both tonsils. The inflammation is generally so severe that an abscess forms in the tonsils which is exceedingly painful until it bursts. It is caused by some poison or by cold, and is common in youth. There is fever, redness and swelling, pain in swallowing, and it generally takes from a week to a fortnight to run its course. Even when swallowing seems almost impossible a little warm milk can be trickled down, for the throat never really closes. Quinsy is much relieved by holding in the mouth hot water in which poppy heads have been steeped. All food taken should be very soft.

There may also be a chronic enlargement of the tonsils that calls for operation. This does not consist, as is often thought, in removing the tonsils, but in cutting a slice off the front of each, which both reduces the size, and, owing to the harder scar tissue that forms, renders them less liable to inflame. Occasionally a relaxed uvula requires shortening, which can be done without pain with a pair of *clean* scissors.

Aphonia, or loss of voice, is not only, as we have shown, a symptom of laryngitis, but may occur independently as the result of the paralysis of one of the vocal cords on which phonation depends.

Catarrh. We now come to a larger class of diseases that involve more extended tracts of the respiratory passages.

Catarrh is the most common of all diseases affecting the respiratory organs and the passages leading to them. It is an inflammation of the mucous membrane that lines all these tracts. If neglected it steals down the windpipe and produces hoarseness and soreness of the chest; if still neglected it may travel along the lungs and become bronchitis, and it may continue still further and become inflammation of the lungs, so that a neglected catarrh may in weak persons end in pneumonia.

The causes are generally a mild specific germ that invades the air passages, coupled with a chill of some sort which lowers the resisting power.

The symptoms are weakness, aching of head, pain across the forehead, running at nose, and perhaps eyes; hoarseness, sore throat, furred tongue, slight rise of temperature, no appetite, and thirst. The mucous membrane is in a state of great irritation, and pours forth a copious liquid secretion at first, which, as the disease advances, gets scantier and thicker, the whole course of the disease, if it does not extend, being from ten days to a fortnight. It can be cut short by treatment in simple cases, which consists mainly in staying in a warm temperature of 60° F. to 65° F. till it is cured. A little paregoric elixir will stop excessive discharge.

Bronchitis. Bronchitis is an inflammation of the bronchial tubes of the lungs as distinguished from the lung tissue inflammation, which is called pneumonia. Distinguishing broadly from leading pulmonary diseases one might say that pleurisy (properly, by analogy, pleuritis—"itis" signifies inflammation) is an inflammation of the outer covering of the lungs; bronchitis, of the air-tubes of the lungs; pneumonia (properly pneumonitis), of the air cells of the lungs; while phthisis is consumption of the air cells coupled with actual destruction of the lung tissues, which does not take place in any of the other three cases.

Bronchitis may well be divided into acute, chronic and capillary. Acute bronchitis is a somewhat dangerous disorder owing to the tendency to spread to the cells and become bronchopneumonia. There is always some fever, ranging to about 102° F.; there is tightness of the chest and short breathing with wheezing. There is a constant, troublesome cough, with some frothy mucous expectoration. The pulse becomes more rapid; there is headache and a general feeling of weakness and illness. It is not common in old people. The cough in bronchitis is of the greatest value in clearing the lungs, and no attempt should be made to stop it. Sometimes there is but little expectoration; the chest is very tight, and the expectoration is dry; in either case the air requires to be moistened with steam from bronchitis kettles.

One form of acute bronchitis is very dangerous, because it principally attacks the very smallest tubes leading to the air cells. It is called capillary bronchitis. It attacks very young children, who die very rapidly from sheer inability to breathe. In these cases the promptest measures are alone of any avail. It is readily distinguished by the bluish colour of the child, and its gasping and fighting for breath.

Chronic Bronchitis. Chronic bronchitis is a common and distressing affection in this country owing to its constant recurrence in the autumn and winter of each year. In chronic bronchitis, or with bronchitis only, there is little or no rise of temperature, but a constant hacking cough, made worse on any exposure or change of temperature and often lasting for months, and not disappearing till the spring. If it be dry, and the expectoration scanty, it becomes more distressing, and may produce emphysema. This consists of the bursting, through strain, of the air cells, so that they form small cavities in the lungs full of air. In this disease, the result of chronic bronchitis, the breath becomes permanently short, and the condition remains even when the bronchitis is gone, from which the lung does not get destroyed. On the other hand there is no restoration of the cells, so that the lungs get overfull of air and over expanded. Such people cannot run or even walk fast. This condition once established persists through life.

The miseries connected with chronic bronchitis are so many that it is a great pity to let

it get firmly established; when any form of bronchitis attacks a person, every effort should be taken to cure it as quickly as possible lest it extend or become chronic. In all these varieties of bronchitis a doctor must be seen.

Pneumonia. Pneumonia is of two distinct varieties—lobar pneumonia, which is a distinct disease, due to a specific germ, and broncho-pneumonia, which generally arises from an extension of bronchitis to the air cells of the lung.

Lobar pneumonia generally attacks one lung, the right twice as often as the left, and the lower lobes more frequently than the upper, whereas consumption almost invariably attacks the upper lobe first. It has a definite cause, and begins quite suddenly like one of the infectious fevers. There is a sudden rise of temperature to 103° F. or more. There is little or no cough or expectoration, but the breathing is hurried, and the face flushed. The whole lung is congested, and but little air reaches the affected lobe or perhaps the whole side. Simple congestion resembles this pneumonia except that there is no fever. The breathing becomes increasingly difficult until the cough begins; with this there is a little scanty expectoration of a rusty colour. It is tinged with blood, which gets more copious as the cough increases. On the tenth day, or thereabouts, a change generally takes place for the better; the temperature falls, and the disease gradually abates till in a fortnight or three weeks the patient's lung is comparatively well again (there being no distinction of tissue in this disease), though the patient remains very weak for weeks after. This disease does not spring from bronchitis, nor does it tend to return like it, nor does it continue indefinitely.

Broncho-pneumonia differs in all respects from lobar pneumonia. It generally invades both lungs and extends gradually. It is nearly always preceded by bronchitis, and is common among children. It runs no certain course, and may continue a long time, and even become chronic. It is more liable to recur than lobar pneumonia.

Pleurisy. Pleurisy is constantly associated with pneumonia, through the inflammation extending through the lung wall to the membrane covering it, but it often arises alone. Between the lung and the chest wall is a double bag on each side called the pleura, containing a small quantity of fluid, so that one surface slides on the other and thus forms a sort of joint as the lung moves. If this membrane gets inflamed the two layers tend to stick together, and when the lung moves a sharp pain or "stitch" is felt at the spot, which is very significant of pleurisy. If the inflammation continues a quantity of fluid is poured out into this closed bag and may amount to several pints, which is generally drawn off by tapping it through the chest wall, as otherwise it takes such a very long time to absorb.

Sometimes a sharp pain is felt in the ribs that is very like pleurisy, which is only neuralgia of one of the veins that run round the ribs to the breast-bone, and is called "pleurodynia."

Asthma. Asthma is a distressing disease which consists of spasmodic contractions of the bronchial tubes for central nervous causes. Fits of asthma commonly occur in the night, when the patient is suddenly aroused from sleeping, and a feeling of suffocation ensues. He is obliged to spring out of bed and rush to the window for more air. The eyes are staring, and the patient feels that he is dying, although asthmatic patients are long lived. The frequency and violence of the attacks depend a good deal on where the patient lives. The disease is often distressing in clear country air, and disappears in a smoky town. A change to the other side of the street even may cause it to disappear. Between the attacks the lungs are healthy and the patient well. When the disease has lasted a long time the patient gets high shoulders from a forced effort at respiration. It is often hereditary, and may last for years.

Phthisis. We now come to phthisis, that dread disease that alone destroys the lung it attacks. This is the most dreadful and fatal disease in this country. Its ravages are still terrible; over 50,000 young people die of it annually. It advances in the patient with noiseless tread, and deceives him with hopes of recovery to the last day of his life. It kills by inches.

The seed, through which alone consumption is propagated, is a tiny micro-organism called the bacillus tuberculosis. It is a small fungus like a rod; 600,000,000 can lie on one square inch, and, if placed in a continuous line, would extend ten miles. They multiply at the rate of 1,000,000 an hour. They are coughed up in countless myriads and expectorated, and as they dry, are blown about to infect all around who are susceptible.

Consumption is now being most vigorously combated, and may be made a notifiable disease. We have already given full information respecting its ravages in different countries in the section on Health [page 5409], under the head of Endemics, and will only add a few particulars about its cause.

It nearly always begins at the tops of the lungs, and there can be no doubt that the exposure of the neck, and, above all, the way in which it is sometimes overheated with furs and at other times left bare, greatly weakens the resisting power of this part.

The left side is that most commonly attacked. The temperature is never steady, but goes up at night, and falls in the morning. The expectoration and cough is frequent. Emaciation rapidly sets in as soon as the lung begins to break down. Cavities are formed, sometimes taking the place of an entire lobe. In this connection, however, the greatest exaggeration prevails, and patients are said to have "lost a lung" when only a few inches of tissue have been destroyed. The tendency of the disease is to spread until death ensues from exhaustion. The spirits, however, keep up to the last, and the patient is seldom gloomy or downcast, while the hectic flush on the cheek gives a deceptive appearance of health.

Continued

CARVING IN RELIEF

The Most Interesting Form of Wood-carving. The Sweep Strokes. How Relief Carving is "Faked." Intaglio and Perforated Work. Foliage

Group 2
CARVING
3

Continued from page 6046

By F. WELLESLEY KENDLE

WE now come to the most interesting of all styles of wood-carving, which consists of rounding down the surface to make it look like a natural object, whether a leaf, an animal, or a landscape.

A Panel in Relief. Set out the panel on white deal [52]. Firm the outline as usual. Ground out and complete the lozenges and ribbons. Sink the grooves BBB between the leaves to their full depth with a V tool. Leaning the tool first to one side and then the other, rough out the curved surfaces. With a flattish gouge model it still more perfectly, furnishing each leaf with a double convex contour, working all the margins to nearly ground level and letting each blend at its root with its fellows. It is better not to attempt to smooth the work piecemeal at this stage, rather strive to get the general effect as a whole; then, and not till then, add the finishing touches with gouges that more nearly fit the curves.

Now chip down the N.E., N.W., S.E., and S.W. corners of the balls CCC (if we may apply the term corner to a circular figure); next, with the concave surface of a flattish gouge lower the wood N and S nearly to ground level; with a tool whose radius is nearly as quick as the circumference of the ball, round it off with a series of sweeping strokes, never making them quite in the direction of the grain, but with a forward, gliding, rotating and ever downward movement of the tool, so that the butt of the handle describes an upward spiral sweep.

50. SWEEP STROKE, FIRST POSITION

51. SWEEP STROKE, SECOND POSITION

The Carver's Freehand Stroke. It is impossible to devote too much time to the acquisition of this particular stroke, which is to the carver what freehand is to the artist. An adept will produce excellent effects with a turn or two of the wrist, while the amateur will flounder about trying to round off a figure by nibbling away at it with straight, pushing cuts; added to this its employment reduces the troubles caused by grain to a minimum.

Having studied the effects of the sweep stroke made with the concave surface of the tool, the reverse must be practised. Again a remarkably bold design is selected [54]. The general moulding is too well indicated to require any explanation; it need only be said that the original fifteenth century font from which it is taken is only carved to the depth of about ⅛ in., the delusive appearance of solidity being suggested by broad bevels, and slight undercuts.

The Reverse Freehand Stroke. Firm the outline and ground out as usual. Rough out the twisted leaf. Take a gouge with an arc corresponding to the curvature of the leaf and not more than ½ in. wide. Let the back of the tool rest nearly flat at A, A¹ [50]. Sweep it onwards with a double curve that leaves the handle perpendicular and the blade at right angles to its first position by the time it reaches B, B¹ [51]. Do this with a continually gliding cut, so that whereas at A¹ the portion of the edge nearest the carver had most of the cutting to do, by the time it has reached B¹ it is practically free, and the other end of the blade is making the final downright cut. If too quick a gouge be used an awkward looking notch is left at the tail of the stroke; if too flat a one, it will probably hitch in the wood half way through the sweep. If the gouge be too small, the manœuvre will have to be repeated once or twice; if it be too large, the feat is almost impossible.

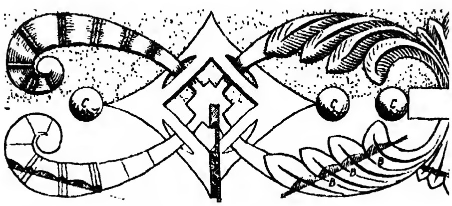
Round the outside of the turnovers. Leave the edges of the leaf high, except at CCCC, where they must be lowered almost to ground level. The notches are cut with gouges held on the slant, bevelling one side and undercutting the other. Model the wavings of the leaves with gouges, noting particularly the rich double wrinkle at DD. Round off the balls, hollow their sockets, and complete by carving the bosses around them, and adding the veins with a V tool.

So all-important are these sweep strokes that a second example has been figured with more numerous but smaller turnovers [53].

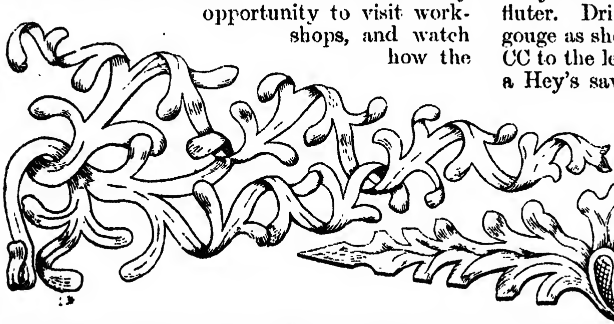
Knowledge of Clay Modelling and Shading. Should doubts arise as to how a subject should be treated, model it first in clay or plasticine. If this be done now it will be noticed that many of the folds in the copy are

out of drawing. This is a common fault, for the carver is not always a first-class artist, and the medium he works in is not the most tractable. So useful are models at this stage that a course of modelling in clay should invariably precede that of carving in wood; the student should also be able to convert an outline drawing into a shaded study [see ART, page 1217, and DRAWING, page 1533].

The More Complicated Designs. Having learned to vein, flute, firm, ground, slope, round, and turnover, the execution of more complicated designs, such as are shown in [56], is simply a matter of combining these several methods. If a man can carve a single leaf or petal, he can, with patience, execute an entire flower. He should seize every opportunity to visit workshops, and watch how the trick is done; he will learn more in half an hour by so doing than in half a lifetime from manuals.



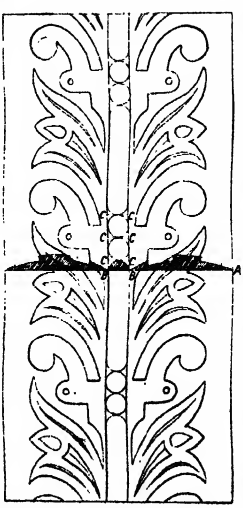
52. JACOBEAN RELIEF CARVING



53 AND 54. CARVING FROM FIFTEENTH CENTURY FONT (PILTON) SHOWING REVERSE FREEHAND STROKE WORK

Modern Fakes. Relief carving nowadays is frequently "faked" by gluing a fret of the design to the panel, and rounding off afterwards. This saves all the trouble of laboriously reducing a large portion of the surface to ground level. A more legitimate application of this was the practice of augmenting the effectiveness of a simple panel by adding a boss or mask, such as may be seen in the panelled room from Exeter, now in the darkest corner of South Kensington Museum. Much of the work executed by Grinling Gibbons's pupils and imitators was not true carving but *appliqué*. Many of the elaborate Devonian mantelpieces, decorated with flowers and drooping sprays, have had each leaf, stem and flower carved separately, glued into position, touched up with putty, and finished off with paint. The French brought this style to great perfection, and adopted *sculpture à la scie* for the reduplication *ad infinitum* of floral wreaths and garlands. Further particulars will be found in "Sculpture sur Bois," one of the *Encyclopédie-Roret* series.

Mouldings and Friezes. For mouldings and friezes the pattern is generally a repeat, and may run either vertically or horizontally. An easy example [55] of the former, taken from the same source as 45, 46, 47, 50, and 52, is given. The shaded portion shows the section. Run out a strip of oak with the moulding plane. Stencil the pattern on the wood. In firming the outline, the tool should always be pointed at the centre of the circle of which the face of the moulding happens to be the arc; by this means a clean edge throwing a pleasant shadow is ensured. At the extremities of the chord, AA, let the ground die away to the level of the surface. Vein with V or fluter. Drill the small holes with a very quick gouge as shown in 33 [page 6043]. Saw down at CC to the level shown in the section at BB, with a Hey's saw; round the balls and the ends of the bolsters as described.



55. JACOBEAN PANEL MOULDING

When cutting mouldings to occupy a horizontal position, this fact must be remembered when the work is on the bench. Take, for example, the familiar "egg and tongue." The sinking cuts, which are necessary to free the wood scooped from the hollow in which the egg lies, must be parallel with the horizon, and each upward sweep must meet it at right angles.

Flutings of pillars and pilasters may be carved with gouges, though it is far easier to run them out with a moulding plane, or a travelling *bur*, leaving the carving tool nothing to do but to trim up the extremities of each. Spirals, which were formerly carved with gouges from start to finish, are now simply turned on a lathe.

A symmetrical twist may be easily obtained by winding a strip of paper, down the centre of which a line has been drawn, round the post to be carved, and marking the wood at its edges. Sink a furrow along this line with a V, keeping it on an even keel, and always at the same inclination to the axis of the cylinder.

56. PANEL IN RELIEF CARVING FROM A SIXTEENTH CENTURY ITALIAN MARRIAGE COFFER

It is most important that this groove should be the same depth throughout if the post is of the same thickness all the way up, or taper gradually should it do likewise. Rough out the curves with flat gouges from the bottom of the furrow to the central line on the paper. Smooth with a gouge that is just a shade flatter than the curve of the spiral; this will give more play, and is less likely to get hitched than one which fits exactly.

Intaglio Work. Still another method of ornamentation is *deep, intaglio* or *die sinking*. This is the exact reverse of relief carving, for the surface remains plain and the pattern is sunk. It is quite easy for any one who has been accustomed to relief work. The main features of the design are scooped out with bent gouges, details are added with quicker tools, and veins added last of all. It is of great assistance to the carver if he takes a squeeze of his work in plasticine from time to time, in order to judge of the general effect. By disarranging the lighting, and causing shadows to fall in a contrary direction, a casual glance will receive the false idea of relief.

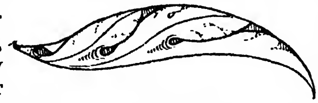
The Value of Keeping Records. Whenever possible, copies should be taken of good work. Putting on one side the obvious methods of sketching and photography, this may be done with a "squeeze." Oil the panel well, and proceed to cover it with sheets of very wet paper, pressing them thoroughly into every crevice; add layer upon layer of coarse brown paper soaked in size or very thin glue. Squeeze out all superfluous moisture. Leave in position to set sufficiently well to permit of removal without danger. When this is dry, plaster of Paris casts can be obtained from it, or others having the appearance of wood itself, by using a mixture of equal parts by weight of gelatine, wood sawdust, and phosphate of lime, moistened sufficiently to make into a stiff paste. Leather well soaked in hot water may be used, or a lump of soap, clay, or putty. Flat carvings may be "rubbed" with heelball or black lead. This procedure is inapplicable to relief; still, a very good general idea of a panel can be obtained by the aid of a newspaper and a rather greasy rag. Press the paper down on the pattern, gently moulding it as much as possible with the fingers; on going over it with the greasy rag the printing ink will be smudged most wherever the relief is highest.

Work in the round is erroneously believed to be the most difficult of all styles to accomplish; in reality it is nothing more than panels in relief carved on both sides. To minimise labour and to prepare the block, it is useful to take a profile of the copy with a strip of lead or malleable zinc. Apply this to the wood, and pencil the outline. Take the opposite profile and transfer as before; then treat the sides similarly.

Carving in the Round. Remove with the saw as much of the waste wood as possible. Next whittle away superfluous material with mallet and gouge, proving progress with the metal guide or with callipers. Should any detail cause anxiety, model it over and over again, or work it out on a soft piece of wood; it is better to devote a few minutes to this than to waste the labour of weeks by perpetrating an irremediable error. Take off too little rather than too much; superfluous wood can be removed, but additions are not so easy.

If he should be nervous about starting—and most novices are—let him begin on some ridiculously easy task, such as sharpening a pencil very neatly or carving animals such as those in a Noah's Ark. Afterwards he may try a poppy head ornament, which he will find to be nothing but two studies of foliage in high relief placed back to back. The human figure and drapery are the most advanced style of all, just as is the case with relief, but the student will find it far easier to hack out a head, or other figure work, in high relief than in low relief.

Tracery and Perforated Work. Tracery and perforated work is an advance upon fret cutting. The ground is entirely removed, leaving lights. It presents no difficulties to the good wood-carver; but it does not pay him nowadays to execute it. Modern machinery with its lathes, planes, bits and burs, can rip out tracery mouldings in a hundredth part of the time in which an expert workman can carve it. So with panel reduplication by mechanical means. It is wonderful to watch a species of glorified pantograph, armed with a revolving bur, copy the design with hardly any manual assistance; but it is not wood-carving, and its servile imitation destroys half its charm.



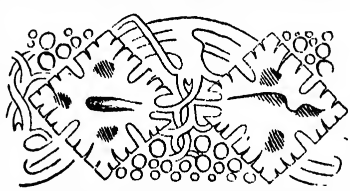
57. ACANTHUS LEAF DESIGN

Foliage. Veins of leaves are frequently carved in relief instead of being sunk with a V tool or fluter. Twin furrows are run along with a V, leaving a medium ridge; the surface is worked down to the foot of this, which is trimmed to shape, tapered at its extremity, neatly joined

at its branchings, and made to die away into the leaf stalk. The macaroni is a handy tool for this work, though it cannot be used close to a junction.

Though the flora of the wood-carver often bears but slight resemblance to that of the botanist, there are certain well-defined points common to each. Thus, veins, though showing as depressions on the upper surface of a leaf, appear as ridges below; remember this when treating a turnover. Noting the general characteristics of a plant, the student will the better appreciate the skill with which the mediæval artist selected and treated his subjects, and will see why it was that the lily, vine, thistle, oak, passion flower, poppy, dandelion, rose, and, above all, the acanthus [**57**] were such universal favourites, and why the coarse and perishable nature of his material led him to limit his efforts to purely decorative adaptations.

The Vine and the Rose. The vine, not only because of its adaptability for ornamental purposes, but also because its religious symbolism, was constantly utilised in ecclesiastical architecture. The carver treated it in two distinct ways. Sometimes the leaf was inscribed within the limits of a symmetrical pentagon, its four eyes and the point of junction with the leaf stalk being arranged at the corners of a similarly shaped but inverted figure. At other times the leaf was placed within the area of a square or lozenge, as may be often noticed on the friezes and crochets of late Gothic work [**58**]. The thistle and dandelion are adapted to follow the lines of acute angled triangles. Both are invaluable for filling in odd corners of tracery.



58. VINE CARVING (ATHERINGTON CHURCH, N. DEVON)

Ivy falls within the lines of a pentagon, and occasionally those of a isosceles triangle.

The rose is conventionally depicted as a symmetrical five-petalled flower, each petal furnished with a fold-over having a bracket-shaped edge. A common sixteenth century ornament was the Tudor rose, the union of the Houses of York and Lancaster being symbolised by the exhibition of both flowers in one boss, one superimposed upon the other, their petals alternating.

The Oak Leaf. Perhaps no other leaf had so many liberties taken with it by German carvers as the oak; they more than conventionalised it, they exaggerated, elongated, stunted, twisted, and folded it, till it became almost unrecognisable. They left it with widely indented margin, rectangular lobes, rugged and misshapen, stunted, gnarled, and bent like its parent tree and yet effective and picturesque.

The acanthus [**57**] is a characteristic feature of renaissance design; at first sight it appears a difficult and complicated subject, but on dissecting its structure it is found to be contained within the limits of two concavo-convex lines, which start from a common point, separate gracefully, and finally coalesce, the leaf bellying and swelling between them. This simplicity of outline is now broken by subdividing each leaf into a number of lobes, the junction of each with its fellow being marked by an "eye." Each lobe in turn is deeply serrated. A vein runs down the centre of each lobe and pipings start from every eye, all losing themselves at a common point. Whether viewed in full or in profile its main lines are always the same, never parallel, never crossing, but each a graceful curve radiating from a common point and strictly subservient to an outline of the greatest beauty and simplicity.

Finishing and Ageing. It cannot be impressed too strongly upon the novice that sandpapering carved work to "make it look smooth" is an unpardonable crime; a few touches with the scraper or rubbing down with a bone are bad enough, but "papering" is the rankest of all heresies. There is nothing to be ashamed of in tool-marks, for at least they show the work is genuine hand-wrought stuff.

To keep the carvings clean light woods may be given a thin coat or two of "egg-shell" varnish; oak and chestnut should be treated to a soaking in boiled linseed oil, followed by plenty of "elbow-grease," using a stiff brush. Beeswax and turpentine should be avoided; they clog the corners of the work and destroy its sharpness. Most other hard woods may be French polished.

It is frequently necessary to stain new wood in order to make it match older work. Apple, pear, and box can be aged with a weak infusion of saffron; lime, ash, kauri and white wood with turmeric or a solution of chloride of tin; mahogany with Brazil-wood. Oak can be slowly darkened with a 2 per cent. solution of bichromate of potash to which ½ per cent. of dilute nitric acid has been added. The process takes a few months, but the tone gained is particularly rich and warm. Veining and figure work can be brought into strong relief by treating first with a weak decoction of madder, and, when this is dry, painting with a solution of acetate of lead.

Blue-black is attained by a decoction of oak galls followed by a solution of green vitrol; jet black by a decoction of oak bark and then perchloride of iron; purple-black by logwood; brown-black by madder and acetate of copper.

Fuming. Oak, and other woods in a smaller degree, can be darkened very rapidly by exposing them, in an airtight box or cupboard, to the fumes of ammonia; but the weaker the dose and the longer the time allowed, the better the result. Storage for several years in a badly ventilated stable loft imparts a tone that cannot be equalled by any other method.

Wood-carvings may be preserved from the ravages of worm and rot by fumigating with calomel, formalin, or corrosive sublimate, by dressing with a solution of alum or of water glass, or, best of all, by impregnating the panel with hard paraffin under heavy pressure at a temperature of about 180° F.

Continued

LINK MOTIONS OF ENGINE VALVES

Action of the Link and its Imperfections. Zeuner's Diagrams. Their Value and Application

Continued from page 6072

By JOSEPH G. HORNER

THE method of operation of the slide valve illustrated on page 5642 is of a simple and elementary kind. No large, high-class engines have such a simple arrangement. But it is necessary to understand the principles, because the more or less intricate valve gears embody the elementary cycle of operations. The most familiar modifications are the various link motions, of which there are about half a dozen good and well-tried types. In England the Stephenson is the best known, but on the Continent the Walschäert is more common. The elements of the link motion may be studied in the Stephenson.

The link—the central feature—is a curved piece, the function of which is to bring about variations in the relations of the eccentrics to the slide valve. Two eccentrics are used, for forward and backward running respectively, and the engine so fitted, therefore, can not only be reversed, but worked at different degrees of expansion. In the extreme end positions of the link, the eccentric and valve rods are practically in line, so that the relations between whichever eccentric happens to be in gear to the valve are identical with those which exist in the simple valve gear without a link. But when the link is in mid-gear, the engine is inoperative. At intermediate positions from full towards mid-gear the cut-off is effected at earlier stages, and with increased expansive working. This is termed by the railway men *notching up*, because the reversing lever is held in notches which are arranged for graduated rates of expansion. When an engine is running light on a level the links are notched up, with economy of steam consumption.

The Elements. The elements of the motion [42] are the two *eccentrics* and sheaves, A, B, the eccentric *rods* C, D, attached to the *link* E, the *die block*, or sliding block, F, over which the link is movable, and connected to the valve rod. To shift the position of the link relatively to the die block, so bringing either eccentric rod with more or less approximation into line with the valve rod, *lifting links*, G, when vertical, or *drag links* when horizontal, are attached to one end of the link. The lifting, or drag links are pulled, or pushed by the *reversing lever*, H, acting through a bell-crank lever on the lifting links. The fulcrum of the bell-crank lever is in the axis of the *weigh shaft*, or rocking shaft J, on which the lever is keyed.

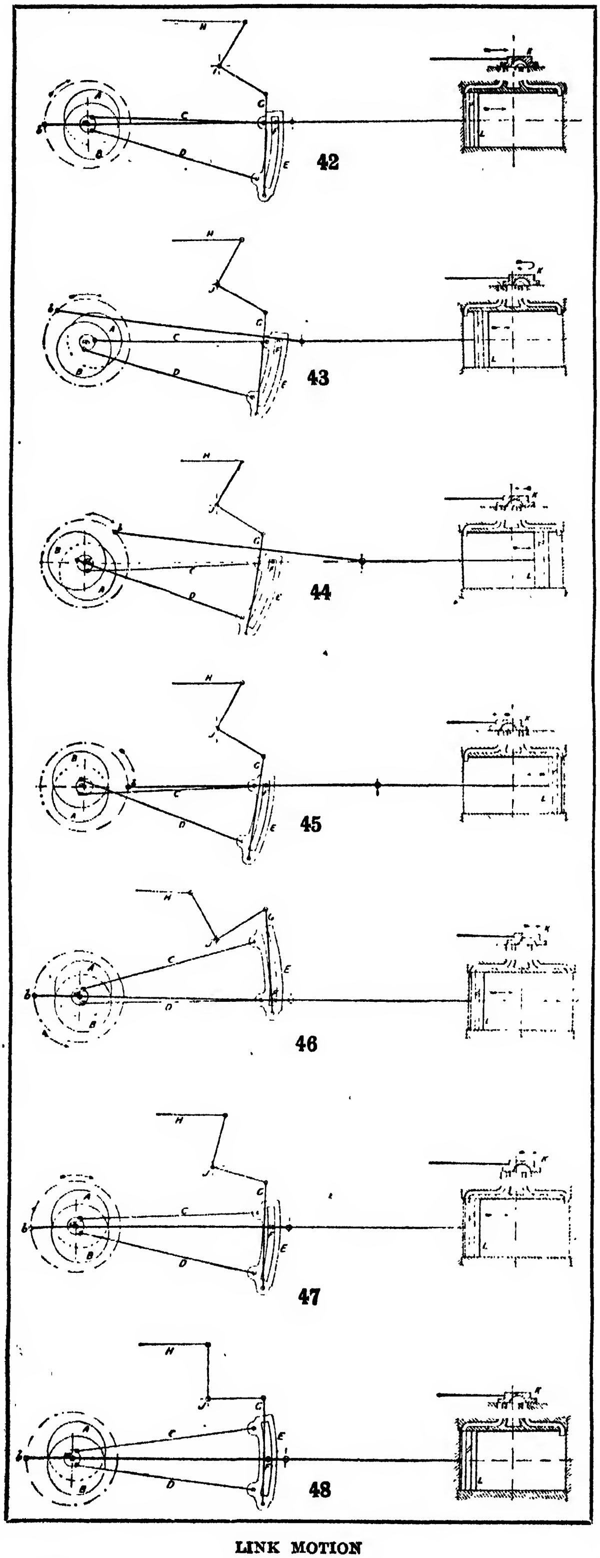
Action of the Link Motion. We shall trace out the action of the mechanism: In 42, in which the engine is on *dead centres*, *a* being the centre of the crank-shaft, and *b* the crank-*pin*, the forward eccentric A will come into operation, and lead, and the engine will run in the direction of the arrow drawn on the circle of the crank-pin. The reason is that the valve K being open to lead—that is, by the amount allowed for lead, say, from $\frac{1}{32}$ in. to $\frac{1}{16}$ in.—steam enters the cylinder behind the piston L, and causes it to move in the direction of the arrow. But in so doing, the crank-pin *b* must move in the direction of the arrow drawn on the crank circle. The full part of the eccentric A still pushes the valve wider open, and more steam enters behind the piston. This goes on until, in 43, the eccentric has advanced far enough to open the steam port to its widest, and then, the centre of the sheave being in line with the valve rod, the valve begins to return. It will be noted that steam is exhausting from the cylinder on the opposite side of the piston. In 44 the valve has returned, and closed the port, cutting off the steam at about three-fourths the stroke, after which the remainder of the stroke is accomplished by the expansive force of the steam enclosed behind the piston. The exhaust port is about to close. In the final stage of the stroke, when the crank-pin *b* is on dead centres, at the opposite side of the path from which it started [45], or 180° therefrom, the forward eccentric A is still 90° in advance plus the amounts of lap and lead on the other side of the centre *a*. The piston has reached the end of its stroke; it is cushioned by the steam entering by the opening to lead, and is about to return. The arch of the valve has opened the port to exhaust, so completing the cycle of one stroke of the piston.

Reversal. If now the link is lifted to bring the backward eccentric into line with the line of dead centres [46], the full part of the eccentric will lead the crank in the opposite direction to that in 42, or backward. This is clear, for though the valve is opened to lead exactly as it was in 42, the eccentric B, in opening the valve, leads and pulls the crank-pin *b* in the direction of the arrow. With the exception that the rotation is in the opposite direction, the sequence of events in the cycle is identical with that in 42 to 45. The opposite end of the link, that which is not brought into gear, is inoperative. It wobbles about, but does not affect the movements of the valve.

The effect of sliding the link in relation to the die-block [47], *notching up*, is to shorten the stroke of the valve, with the result that steam is cut off earlier, and worked at a higher ratio of expansion. But it also increases the opening to lead, and with it the amount of back pressure or cushioning.

If the link is brought into mid-gear [48] the valve will be open to lead at the termination of a stroke, but no motion can ensue, because the port becomes covered at once. But for the lead and lap no motion at all would ensue. An engine with the link in mid-gear would not run, though the throttle valve or regulator were wide open.

Imperfections. Around this common link motion much variety in practice exists, for it is only a compromise, and it lies mostly round the allowances for lap and lead, and especially the latter. Too much lead would be an evil in a slowly-running engine. The obliquity of the rods exercises a considerable influence, and to this is due the fact that the aim is generally to make the rods as long as is convenient, to lessen this obliquity, just as connecting-rods are made long preferably to being short. For the same reason the links are made as short as convenient, because bringing the centres of attachment of the rods closer together lessens their



LINK MOTION

obliquity. For the same reason, rods are made *open*, rather than *crossed*, when the full part of the sheaves comes between the crank axle and the link. They become crossed when the full part of the sheaves lies on the side of the crank-axle which is farthest from the link. The effect of crossing is to shorten their radius, because of their greater obliquity. This explains why the lead is greater at one end of the cylinder than at the other, greater in **45** than in **42**. This increase will be minimised the more the length of the rods is increased. The reason why lead is increased by crossing the rods is illustrated in **49**, where the rods, open, are shown at C, D, and the same crossed at C′, D′; *a* being equal to twice the lap and lead, *b* is the extra amount of lead due to crossing the rods. The reason why lead is increased by moving the link from full gear towards mid-gear is apparent from the diagram in **50**. When the engine is in full gear forward, the centre of the pin of the forward eccentric rod is at *a*, and that of the backward rod at *b*. By lifting the link to the centre, the rods describe arcs round their sheaves. The centre of the link is thus thrown farther away from the crank-axle by the distance *c*, with corresponding increase of lead.

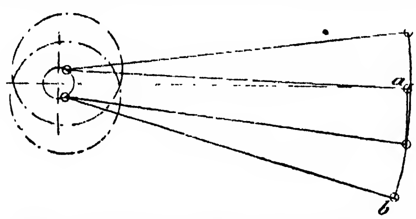
To neutralise the effects of increase of lead at one end of the stroke the general rule holds good: "Draw the centre line of the link with a radius equal to the length of the eccentric rods, measured from the centre of the joint at the other end."

Zeuner's Diagrams. The relative positions of crank and slide valve can be obtained by means of Zeuner's diagrams as follows. The principle is shown in **51**. Here *ab* represents the length of the connecting-rod, and *bo* that of the crank, *o* being the centre of revolution of the crank shaft: *cd* represents the length of the eccentric rod; and *od* the eccentricity or throw of the eccentric, *d* being in advance of the crank-pin *b* by 90° plus the angle of advance θ of the eccentric sheave. The length *ab* of the connecting rod may be set off from the extremes of the crank circle at *ef* to *e′f′*, which will give the length of the piston stroke. By setting off the length *dc* of the eccentric rod from the valve circle at *hi* to *h′i′*, the length of the valve stroke can be obtained.

Now draw *bj*, *dk* perpendicular to the line which represents the axis of movement of the piston-rod. Neglecting the obliquity of the connecting rod, *ej* will represent with sufficient approximation the distance *e′j′* through which the piston has moved at the position *b* of the crank. Set off *oc′* equal to *dc*, and *c′* will correspond with the mid-stroke of the valve. The valve has moved a distance of *cc′* from its mid-position for the position *d* of the eccentric sheave. Since *oc′* equals *dc* very approximately, therefore *ok* is

approximately equal to cc'. Next take half the radius od in **51**, and with it draw two circles in contact [**52**]. Draw ok' parallel with od in **51**, and join $d'k'$. Then, in **51** and **52** od equals od; the angle $d'ok'$ equals the angle dok, and the right angle $ok'd'$ equals okd. Therefore $d'k'$ is the radius vector, which is the line from the centre of the force to the point of the orbit where the body is supposed to be. This, if drawn parallel with any position of the eccentric will be approximately equal to the travel of the valve from its mid-position. In other words, the amount of movement of the valve is the same as the radius vector corresponding with that angle. Hence, by the embodiment of this diagram, the distance between the centre of the valve and its centre of movement for any position of the crank can be measured without calculation.

To apply the principle embodied in the diagram, the circles are rotated back through an angle of 90° plus θ, the angle of advance of the eccentric, as in **53**. This is done as a matter of convenience. The angularity of the eccentric rod being so small as to be negligible, as is evident in **51**, which is drawn to scale, and the radius vector being, therefore, approximately equal to the travel of the valve from its mid-position, all that



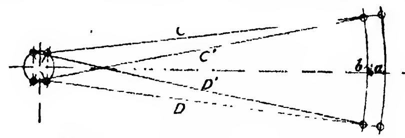
50. INCREASE OF LEAD TOWARDS MID-GEAR

remains is to bring this into line with the line of the crank. In **53**, take two lines at right angles with each other, aa, bb, and from aa set off the angle of advance θ towards the initial position of the crank, and draw the line cc at that angle. Then draw two circles in contact from centres $o'o'$, oo' being equal to half the radius of the eccentric. Then the radius vector od of the valve circles, drawn from o parallel with any position of the crank corresponds with the travel of the valve from its mid-position.

Completed Diagrams. The foregoing are drawn to the same relations and scale as the diagrams in **51** and **52**. But as it is impossible to be quite accurate when the valve circles are so small it is usual to draw these to an enlarged scale. The next figure, **54**, therefore shows them four times larger than the previous figures do. The valve diagram is here shown completed; bb' is in the path of the piston-rod, and aa is at right angles thereto; bb' is the crank circle, and the crank is moving from b' to b.

Draw the line cc at the angle of advance θ from $b'b$. Measure off od, oe, each equal in length to half the travel of the valve, and with centres $o'o'$ on these lines draw the two valve circles. The crank circle bb' is drawn to any scale or to full size. With centre o and radius equal to the outside lap draw the outside lap circle ll. If inside lap is put, then, with centre o and radius equal to the inside lap, draw the inside lap circle 2.

The port opens to steam when the valve has moved from its mid-position through a distance equal to its outside lap. A line, the radius vector,

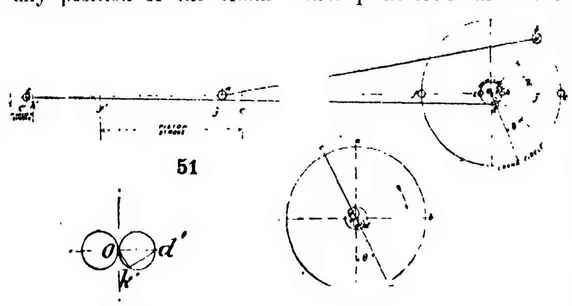


49. OPEN AND CROSSED RODS

drawn from o through the point i on the valve circle to cut the crank circle at i' shows the position of the crank when the valve opens. o 3 4 is the position of the crank when the valve closes, and the steam begins to work expansively. o 5 6 is the position of the crank when the valve opens to exhaust, and o 7 8 that of the crank when the valve closes to exhaust, and compression begins. On the lines drawn below **54**, the proportionate lengths of stroke of the valve rod are shown; o 4 is the period of admission, 4 6 that of expansion, 6 8 that of exhaust, and 8 2 that of compression.

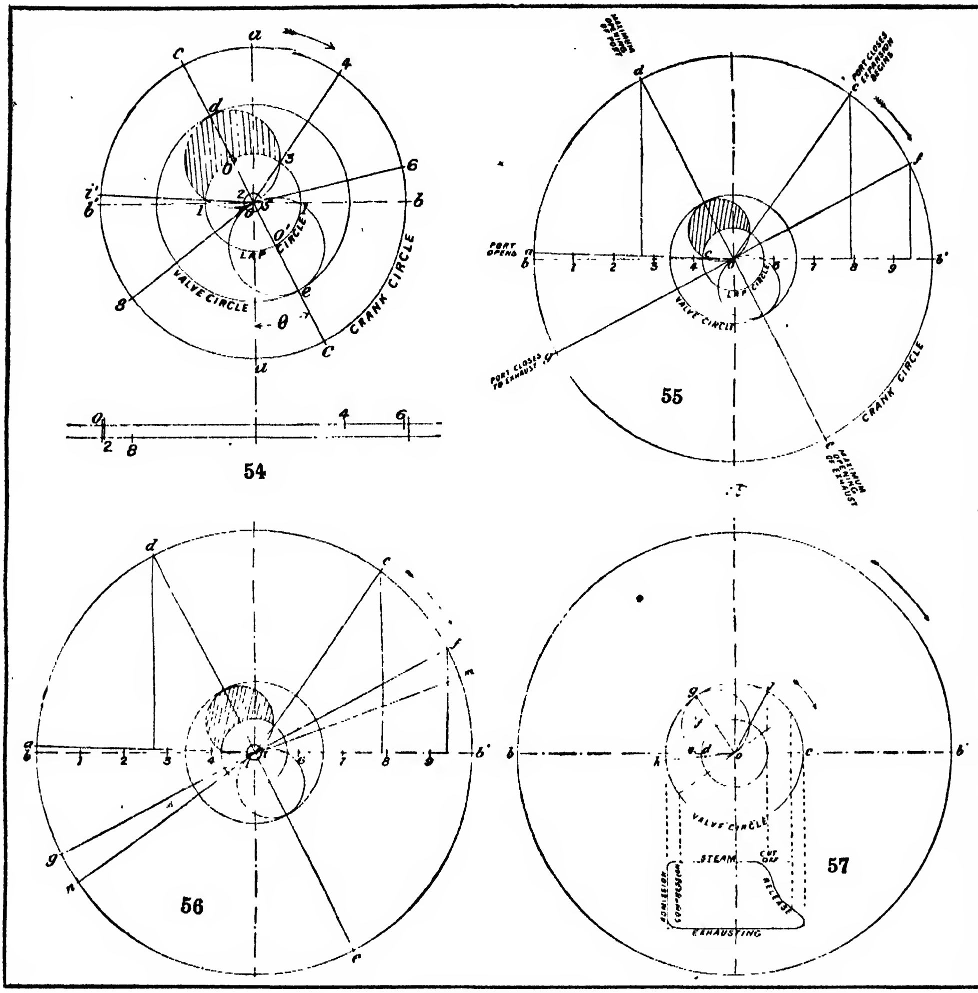
Another way of illustrating the valve diagram, though identical in principle, is shown in **55**. Draw the crank circle bb' of the same diameter as the stroke of the piston, and mark a line bb' across its diameter. From the same centre describe a circle, the "valve circle," the diameter of which represents the length of travel of the valve. From the same centre describe the "lap circle," the diameter of which equals twice the lap.

When in the plane bb' the crank is on dead centres. But if lead is allowed the port opens before the crank arrives at dead centres—namely, at the point a on the crank circle. This can be obtained by setting down on the valve circle the proportion which the lead bears to the total travel of the valve—it may be one-fortieth, or one-fiftieth, or other proportion of the travel—and drawing a line through that point from the centre o to cut the crank circle at a. This line will cut the lap circle at c. A circle is now drawn of half the diameter of the lap circle cutting the lap circle at c. The portion of the circle lying outside the lap circle is shaded in order to indicate the amount of opening of the port, as separated from that of the lap, and the two extremities, as shown in the previous diagram, mark the points of opening and closing up the ports. The line oa is that which corresponds with opening, and the line oc with closing. On the radius od on the centre of the shaded portion the maximum width of port opening is measured. And in any position included by the arc of admission the width of opening of the port can be measured on any radius on the shaded area. Similarly, the line od prolonged to e gives



51 52 53

PRINCIPLE OF VALVE DIAGRAMS



VALVE DIAGRAMS

the maximum exhaust opening. And if there is no lap to exhaust, the exhaust will remain open during half a revolution, and therefore a half circle measured equidistantly from *e* will give the entire exhaust opening, being at its maximum at *e*, and closing at *g*, beyond which compression takes place to *a*.

Uses of Diagrams. It is easy to ascertain from the diagram the distance which the piston has travelled corresponding with any width of port opening. Suppose the length of stroke is divided into ten equal parts, as shown. Then perpendiculars dropped from any points in the crank circle indicate at what positions of the piston the various stages in the valve cycle take place. If there is no exhaust lap, the edges of the arch of the valve coincide with the inner edges of the steam ports when the valve is in the middle travel. Then the opening and closing of the exhaust ports will be represented by lines at exact right angles with those representing the maximum port opening, as in the present figure [**55**]. If exhaust lap is added, the diagram is modified, as in **56**. A circle is struck from the common centre with a radius equal to that of the lap. A second circle is drawn equal to the upper circle, which will indicate the port opening for the return stroke. Through the points *i* and *i* where this circle cuts the exhaust lap circle lines are drawn cutting the crank circle at *m* and *n*; *m* represents the opening to exhaust and *n* its closing.

Another way to draw the diagram is shown in **57**. Draw the centre lines *bb'*, and from a centre *o* describe a circle *c*, the diameter of which is equal to the travel of the valve. Mark off from the centre *o* the lap *d* and lead *e*. From *e* erect a perpendicular *f*, cutting the valve circle at *g*; join *og*, and on the line *og* describe a circle in contact with *o* and *g*. From the centre *o* draw the lap circle *cd*. Draw lines from *o* passing through the points of intersection of the two circles, and cutting the valve circle at *hj*; *oh* then represents the position of the crank when the valve begins to open the port to steam, and *oj* corresponds with the cut-off. To render the relations more clear, an indicator diagram is drawn below, showing admission, and full opening, cut-off, expansion, release, exhaust, and compression.

Continued

CIRCULAR SAWS

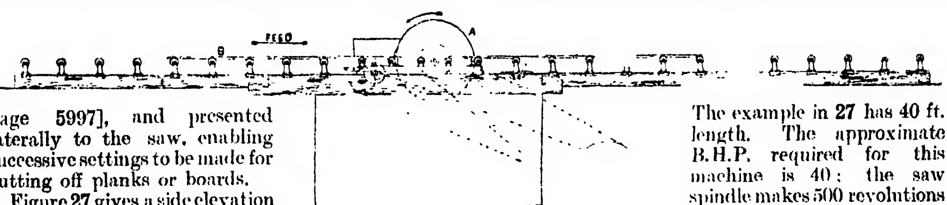
Rack Benches. Re-sawing Machines. Benches with Rope, Chain, and Roller Feeds

Continued from page 5997

By FRED HORNER

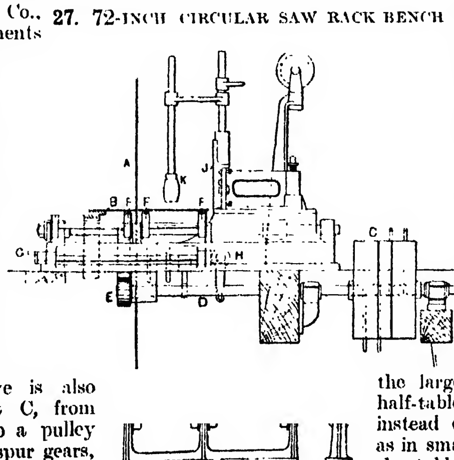
WE shall now consider the circular saw as a log-converting machine. It possesses the advantage of great speed of cutting, and outdistances the reciprocating saws easily in this respect. As a set-off, however, two objections are found: there is a considerable waste of wood in the kerf, and the saw takes an excessive amount of power to drive it, due to the leverage of the teeth acting on the periphery of the disc. Notwithstanding these objections, circular saws are employed when logs have to be cut into heavy scantlings, such as sleepers, posts, and various framings of square or other sections, which involves taking off the outside portions. They are not used to such an extent for the cutting of logs into very thin boards or strips of different sections, although the smaller saws are adapted to deal with pieces that have already been broken out from logs. The Americans are fond of using circular saws for log work, and manufacturers devote more attention to these machines than they do over here.

Rack Benches. The log saws are constructed with travelling tables, which carry the logs past the projecting saws. There are two patterns: one in which the tables are divided to embrace the saw on each side, the other in which the logs are held on dog-carriages resembling those in **26** [see page 5997], and presented laterally to the saw, enabling successive settings to be made for cutting off planks or boards.



27. 72-INCH CIRCULAR SAW RACK BENCH

Figure **27** gives a side elevation of a *rack bench* for a 72-in. saw (Messrs. W. B. Haigh & Co., Ltd.), from which the elements of such machines may be studied. In **28** some of the details are illustrated. The saw, A, runs in fixed bearings, and the timber rests upon the table, B, which has a longitudinal opening to receive the saw. The table is made of steel plate, and moves upon a series of rollers, seen underneath, resting upon a timber framing. The driving of the saw is effected through the line shaft and pulley at C, belted up to the saw mandrel; the table drive is also derived from a pulley at C, from which a belt goes up to a pulley connected to a train of spur gears, coupled with the rack underneath the table. The rates of feed can be varied from 10 ft. to 40 ft. per minute, with a quick return movement at 120 ft. per minute. Some details of the machine are illustrated in **28**, the saw being seen at A, the table at B. The feed is from pulleys at C, carrying open and crossed belts, either of which is shifted on to the central fast pulley, driving the shaft D, and thence a train of spur wheels, which end in a pinion meshing with the rack fastened underneath the table, B, to the left. The four rollers supporting the table across its width are seen at F F F F, all of these being mounted upon a common spindle. There is a foot pedal at G, which, when depressed one way or the other, turns a short shaft, having mitre gears communicating motion to a rocking lever at H, which operates a rod connected to the striking forks on the pulleys at C, thus giving the attendant perfect control over the feeds and return. The *fence* at J is for guiding timber in a straight line past the saw, and to keep the timber against the fence the *pressure roller*, K, is brought into use. It is held on an upright bar that can be pivoted in its socket, and pulled over by a cord attached to a balance weight, the cord passing over the pulley adjacent. In this manner the timber is pressed up to the fence, and the resulting cut is parallel and smooth. The length of the tables in these rack benches ranges between 20 ft. and 40 ft. The example in **27** has 40 ft. length. The approximate B.H.P. required for this machine is 40; the saw spindle makes 500 revolutions per minute, and the greatest possible depth of cut which the saw can make is 32 in. In the case of a 42 in. saw machine the capacity in depth is 18 in., and the H.P. 20. These saws are speeded to give about 9,000 ft. peripheral speed.



28 DETAILS OF RACK BENCH

Figure **29** shows the general appearance of a rack bench (Thomas Robinson & Son, Ltd.), in which the rollers at one end are seen exposed as the table is travelling towards them, carrying a log upon it. The tables in this type of machine are of steel, and in the largest sizes of machines each half-table is driven by its own rack, instead of employing a single rack, as in smaller machines. Parallel with the table, and at the same level, are a series of plain rollers for shifting the timber about, both before and

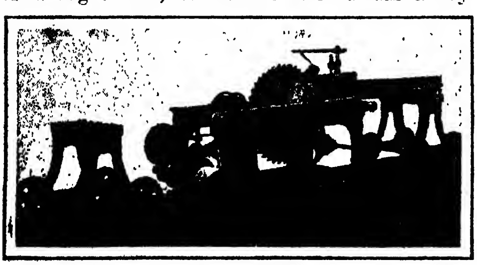
29. CIRCULAR SAW RACK BENCH

after it is sawn. These may be noted at the left-hand side of the table rollers in the picture.

Hand-fed rack-tables are made only to a moderate extent, the motion being obtained from a crank handle turning the rack pinion. The table is made of wood, with iron guide rails bolted beneath, and the framing is of wood, made in such portions that they can be conveniently transported to out-of-the-way districts. The tables are shorter than those for the largest power-fed machines, ranging from 12 ft. to 20 ft. The term *colonial* is often applied to these classes of machines. The sawmill engineers simply supply the iron portions of the machine, leaving the purchaser to construct the timber work on the spot, or within convenient reach of the forest.

The reason for the adoption of wrought-iron or steel plates in these rack benches is chiefly one of strength, because cast iron is liable to be fractured through the concussion of heavy logs rolled on to them. No fastenings are necessary for the logs, as the weight is sufficient to keep them steady. Round logs are flattened a little on the bottom to make them stand firmly, or else wedged and packed to keep them from shifting.

Rack Benches with Dog-carriages. In what are erroneously called American rack benches the log is not carried upon a flat table, like the foregoing, but is held in a dog-carriage, by which it may be fed up to cut off planks and boards of various thicknesses, the operation being similar to that of the vertical log band-saws described in the previous article. These machines are used more extensively in America than over here, but the band-saws are gradually displacing them, for the reasons already given—namely, less power consumption, and decreased width of kerf. In America, also, the use of large saws with inserted teeth is far more common than in Britain, the waste of wood being excessive. These saws will be described, together with others, later. The description of the dog-carriages given in the previous article applies equally well to those employed for circular saws, and need not be repeated. In **30** we illustrate a machine (Messrs. Thos. Robinson & Son, Ltd.), in which a log is seen gripped by some of the quick-acting dogs of the carriage. The latter is constructed wholly of wrought iron, so that it can sustain heavy shocks and cut at a high speed without risk of breakage. The carriage as shown is arranged to take logs up to 30 ft. in length, but there is practically no limit in this direction. The circular saw is 66 in. in diameter, and runs at 500 revolutions per minute. There are three speeds, or rates of feed, to the log, and a rapid return.



31. SAW BENCH WITH ROPE FEED

A circular steel disc of wedge section is placed immediately behind the saw, to enter the kerf after it, and force the two sawn portions apart slightly, thus relieving the saw of undue side friction, which would tend to heat the saw, greatly augmenting its work and decreasing output. There is a long vertical roller located in a sliding bearing in advance of the saw, against which the log takes a bearing when travelling. The roller is adjustable by a hand wheel, and serves as a fence.

Double Saws. As the capacity of a circular saw is limited as to the diameter it will cut, it cannot be employed to cut up big logs. But by mounting another saw above, the capacity is much increased, as the two blades, working up from below and down from above, can reach through a greater thickness. The top saw is usually of smaller diameter than the bottom one, say in the relation of 72 in. and 36 in., in the case of the larger machines. Figure **32** represents a double machine, a type similar in all other respects to **30**. The upper saw is carried on a spindle in sliding bearings on an upright, and the driving belt passes around a jockey pulley by which the slack is taken up. The teeth of the saws face in opposite directions to each other, and the direction of rotation is also opposite. The two are brought as close as possible without actually touching.

30. CIRCULAR SAW LOG MILL

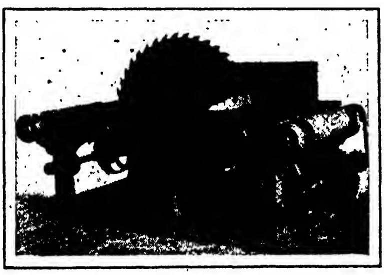
Framings. The framework of carriages is generally constructed of timber when intended for export purposes, and the American builders of these machines favour timber framings, on which the running wheels, the dogs, and the set works are fastened. The timbers are mortised and tenoned together, and well secured with bolts. The frame carrying the saw mandrel and the feed-change works is also of wood. The reverse motions are put into action by friction wheels. Other classes of feeds are the rope or cable, and the direct-acting steam (used chiefly in America), discussed in the last article.

The driving arrangements of the circular log mills depend on circumstances. The power can be derived from a special portable engine, belted to the raw mandrel, or from main shafting which serves other machines. An oil or gas engine can be located close to the mill, and belted to the pulley. The oil engines are useful for portable mills, or those which have to be re-erected from time to time in various parts of the forest.

Re-saws. We now come to a group of machines termed *re-saws*, the function of which is to cut up deals, flitches, planks, etc., which have already been sawn out from logs, into portions of various sizes. The deal frames already described are strictly re-saws, but there are also the smaller band and circular saws, which are both rapid in operation and handy in respect of the variety of work which they can be adapted to turn out. Adjustments can be made very quickly to cut a small number or hundreds of similar pieces. A feature in which these circular and band re-saws differ from log-sawing machines is that the tables do not usually travel, but the timber, being more or less even, is slid along smooth surfaces, with or without the help of rollers. The three chief methods of feeding are rope, chain, and roller. The *rope-feed* is suitable for irregularly-shaped timber, or for driving small logs. The bench [**31**] (Thos. Robinson & Son, Ltd.) embodies a cored casting, carrying three bearings for the saw spindle. The timber is drawn along on the top of the table past the saw by a rope, fitted with a drag hook at the end, as seen, and the rope is wound around the drum at the left-hand end of the bench. Four rates of speed, from 15 ft. to 60 ft. or upward per minute, can be obtained through the medium of cone pulleys, and the movement of the rope can be instantly started or stopped by throwing a clutch in or out of gear. The speed of the drum is reduced by back gears. The rope is passed up over a roller at the edge of the table, this roller enabling it to run over the edge without friction. In cutting long pieces, which overhang the ends of the bench to a considerable distance, some extraneous support is required; this is afforded by a *trolley* at each end, running on lines of rails laid down in line with the machine. The timber, therefore, rests on one trolley, and gradually leaves it, to pass over the bench past the saw and be supported by the other trolley. The fence for keeping the timber straight is fitted with a counterbalanced roller, pulled over by a weight, in a similar manner to that described in connection with **28**.

32. DOUBLE SAWS FOR LARGE LOGS

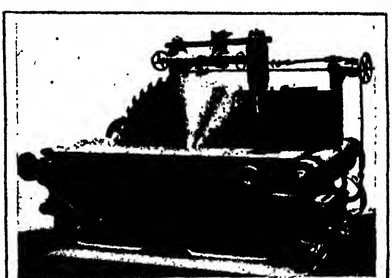
Some rope-feed benches have, instead of the small drum, a large grooved wheel placed with its spindle at right angles to the saw mandrel; it lies close up to the end of the bench, and the rope is conducted over a small pulley on to the table. The rope is subjected to less strain while running on the large pulley than it is on a small drum. When the rope has been pulled along to its drum or wheel, the return, in readiness for another feed, is effected by pulling at it with the hands, the clutch being thrown out meanwhile, so that the drum revolves freely upon its spindle.



33. HORIZONTAL ROLLER-FEED SAW BENCH

Chain-feed Benches. *Chain-feed* benches, which are employed principally for cutting up sleepers and the various short pieces of waggon framings, have a greater output than the rope-feed machines, because the action is continuous. One, or in some cases, two endless pitch-chains are driven over wheels at the ends of table, and they run in grooves past the saw. The timber is fed by the pressure of dogs dropped on to the chains between the links. As the chain or chains are always running, the timber can be pushed along as fast as it is placed in position. Rates of feed vary from 40 ft. to 120 ft. per minute. Some of these machines will split 2,500 balks in a day of ten hours, resulting in the production of 5,000 sleepers.

Roller-feed Benches. The best method of feeding, providing the work is suited thereto, is by continuously revolving *rollers*, either horizontal or vertical, the latter method predominating. A horizontal roller bench is shown in **33**, one of Messrs. Robinson's designs. The rollers, which are smooth, lie at the ends of the table, and their top surface is raised slightly above that of the table. They are driven at any one of three different speeds, and the weight of the log, or flitch, combined with the downward pressure of the revolving saw, gives sufficient friction to feed. The rollers can be reversed at a quick speed, in order to return heavy pieces after each sawing. The largest of the machines takes saws up to 5 ft. in diameter.

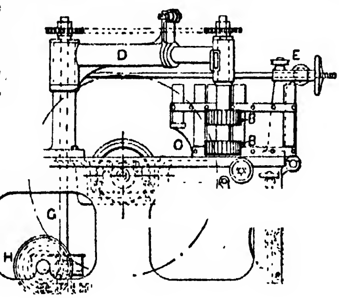


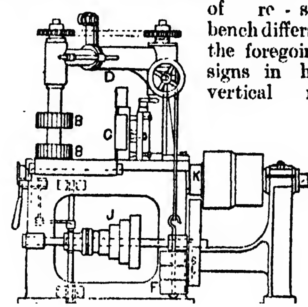
34. SAW BENCH WITH COMBINED HORIZONTAL AND VERTICAL ROLLER FEEDS

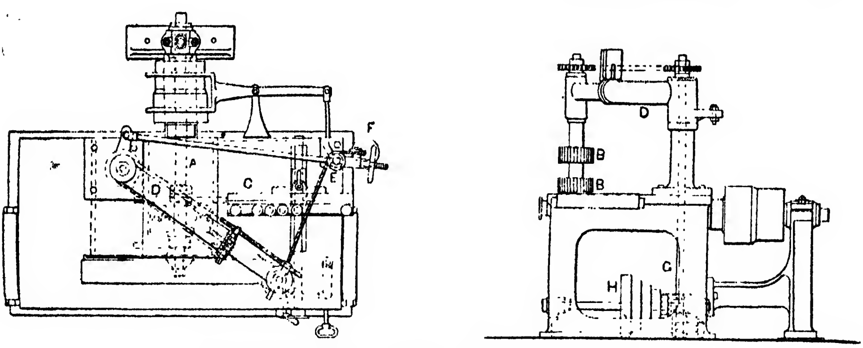
One of the most useful forms of roller-feed bench is that shown by the drawings in **35** of a bench taking 42 in. saws, and having a table measuring 6 ft. by 3 ft. The example is one by Messrs. John Sutcliffe & Son, Ltd., Halifax, and shows it in side elevation, plan, and two end elevations. The saw spindle, A, is supported in two bearings, the outer one being placed outside the driving pulley; the latter is made slightly larger than its adjacent loose pulley, on which the belt is slid to run idle and slack. The belt shipper is seen to be actuated by a pivoted lever worked from a rod passing through to the front of the bench, where the control is best effected [see the plan view]. Removable plates are fitted over the bearing and the spindle end to facilitate examination and the changing of saws. The feed rollers BB, serrated in ratchet form, are revolved against the timber, and force it along while making contact

with the fence C. A number of small plain rollers are set in the fence, to relieve the friction. Lateral adjustment, to suit the thickness of wood which it is desired to cut, is effected by a transverse screw passing through the table, and turned by a small knob seen near the right-hand end. Quick adjustment is provided for by a locking handle, which releases the fence, enabling it to be shifted to and fro instantly.

The mechanism of the feeding rollers includes a radial arm, D, pivoting upon a pillar bolted to the table, and carrying a rod in clamp bearings, which rod holds the vertical shaft bearing of the rollers, and is adjustable in the clamp bearing to accommodate different diameters of saws. Pressure against the wood is produced by a rope or chain pulling at the side of the bearing, leading over guide pulleys at E, to a weight at F. The rollers are driven in a positive manner by a pitch chain on the top of the shaft, worked from another shaft, G, which passes down through the table pillar to the floor, where a worm drive is received from a four-stepped pulley, H. belted from another pulley, J, which derives motion from a pair of pulleys, one on its shaft, and one on the saw mandrel, at K. A claw clutch, put into mesh by a handle at the front of the bench, enables the sawyer to start and stop the rollers instantly; the clutch works into teeth on the stepped pulley. At each end of the bench a smooth roller rests in bearings to take the weight of the wood as it passes over, and so to lessen the friction. If it is desired to use the machine without the roller feed, the radial arm can be swung out of the way, leaving the bench free.







35. CIRCULAR SAW BENCH WITH ROLLER FEED

Combination Feeds. Several types of benches are constructed with a combination of feeds, as rack and roller, or rope and roller, the idea being to use one for rough logs, which cannot be fed by rollers, and the other for regular pieces, like deals. Such machines are very useful to sawyers who cannot have two separate benches for the different classes of work. Messrs. Robinson make a bench [34] which incorporates the horizontal and the vertical rollers. The details will be clear from the illustration. The vertical rollers are adjustable vertically upon their shaft, to suit varying heights of timber. The reason for the adoption of two rollers is that a better grip is secured on the timber. When the horizontal rollers are in use, the radial arm is pushed round to the back of the bench.

In one type of machine the feeding is imparted by a fluted roller, which projects through an opening in the table in front of the saw, the amount of projection being variable, to suit the nature of the timber. In all these roller-feed benches, the stuff can be fed continuously, and the length of time during which the saw will be running idly is reduced to a minimum.

Canting fences, are designed for use with the roller-feed benches, to cut feather-edged boards, etc. The fence tilts bodily with its rollers, so throwing the stuff over in relation to the saw. A special class of re-sawing bench differs from the foregoing designs in having vertical rollers duplicated at the end, by means of which the deal or batten can be passed through and be divided exactly in halves by the saw, the rollers being self-centring. At the same time, the machine can be adapted to sawing boards of varying thicknesses by locking one of the rollers and using it as an ordinary fixed fence. A canting movement is fitted in certain cases, to throw the stuff over for cutting feather-edged work.

In these machines the table is represented by narrow ledges only, just sufficient to carry the width of stuff being dealt with.

Saws are duplicated on a spindle in some cases for making more than one cut along a piece of stuff, with the idea of saving time and producing repetition work. Some of the chain-feed benches are constructed with a saw flanking each side of the chain, for edging deals and boards after they have left the log frame. Small logs may also be squared on two sides simultaneously.

Continued

REFINING PETROLEUM

Petroleum Oil and its By-products. Shale Oil. Uses of Petroleum and its Products

By Sir BOVERTON REDWOOD

THE object of the operations which are collectively known as the refining of crude petroleum is to separate the liquid into a series of products best suited for various industrial uses. Crude petroleum as it comes from the well has already been shown to consist chiefly of a mixture of hydrocarbons or chemical compounds of the two elements hydrogen and carbon. These hydrocarbons exhibit a progressive range of boiling points, those at one end of the scale boiling at common temperatures, whilst those at the other end require to be heated to many hundred degrees Fahrenheit before entering into ebullition.

Fractional Distillation. It is, therefore, obvious that if we apply a gradually increasing heat to the crude petroleum we shall successively convert one constituent after another into vapour in the order of their boiling points, and if we pass this vapour through a tube surrounded by cold water we shall cause it to return to the liquid condition. The liquid so obtained may evidently be collected in as many separate portions as we wish, and we have thus the means of dividing and subdividing the crude oil into various products. The process in question is termed *fractional distillation*, and the separated liquids or distillates are called *fractions*.

Stills and Condensers. On the practical working scale the fractional distillation is carried out by the use of a still and a condenser. The still usually consists of a horizontal cylindrical vessel of iron or steel plate, with a dome, like that of a steam boiler, from which a tube or vapour-pipe passes with a slight downward inclination to the condenser. The still is set in brickwork, and is heated by a furnace. The condenser commonly consists of a coil of iron tubing, or a series of straight pipes joined by curved pipes or bends, placed in a tank filled with cold water. The outlet end of the condenser passes into a trough arranged so that the stream of liquid issuing from the condenser may be diverted into various receptacles.

Products. When ordinary crude petroleum is heated in such a still the first commercial product which flows from the condenser is petroleum spirit, or benzine, and this is allowed to flow into the tank provided for it until the temperature of the contents of the still has risen to such a point that distillation of the next commercial product—namely, the petroleum oil or kerosene, for use in lamps—begins. The stream of distillate is then diverted into the kerosene tank until the whole of this product has been obtained.

On further increase of temperature oils of higher boiling point, intermediate in character between the kerosene and the lubricating oils, distil over, and, lastly, lubricating oils of various grades issue from the condenser, these containing the solid paraffin wax if the crude oil undergoing distillation contains this substance, the residue in the still consisting of coke if the distillation is carried to *dryness*, as it is termed.

Usually the process herein described is conducted in two parts, the benzine and kerosene being separated in one still, and the distillation being completed in another still to which the residual oil is transferred. In some districts, and notably in Russia, only a small proportion of the residue which remains after taking off the benzine and kerosene is further distilled, the greater part of the residue being sold as liquid fuel. Where the distillation is carried to dryness, the operation is completed in cast-iron stills, the bottoms of which are of hemispherical form. In the distillation of the lubricating oils it is customary to inject steam into the stills, as this tends to prevent the products being injured by overheating, and facilitates the passage of vapour from the still to the condenser. On the other hand, in the distillation of the kerosene, overheating is often aimed at, the yield being thus increased by what is known as "cracking," which is the conversion of some of the heavier constituents of the crude oil into lighter ones of lower boiling point.

The benzine distillate is re-distilled with the aid of steam, so as to subdivide it into the various commercial products, including motor spirit.

Continuous System of Distillation. The process of fractional distillation which has been described is known as the *intermittent* system, because the still has to be periodically re-charged. In conducting the process of *continuous* distillation, which is the system commonly adopted in Russia, a series of stills is employed. The second of the stills in this series is heated to, and maintained at, a higher temperature than the first, the third to a higher temperature than the second, and so on throughout the series of ten or a dozen, or even more, stills. The crude oil is caused to flow slowly through the whole series, being thus subjected to a gradually increasing heat, while the temperature of the contents of each still remains practically constant. Under these conditions each still continuously yields a product of given boiling point corresponding with the temperature at which it is maintained, and the loss of time, waste of fuel, and injury to plant involved in cooling down and re-heating the stills in the intermittent system are avoided.

Benzine and Kerosene. The benzine or benzine products and kerosene are purified by agitation successively with sulphuric acid and a solution of caustic soda, followed by washing with water, and when the crude oil contains sulphur a special process is also adopted to remove this impurity from the distillates. The agitation is effected by means of compressed air, the operation being conducted in vertical cylindrical iron vessels termed agitators.

Lubricating Oils and Solid Paraffin. The lubricating oil distillates obtained from crude petroleum containing solid paraffin are artificially cooled to a low temperature, when the paraffin crystallises out and is separated from the oil by means of filter presses and hydraulic presses. The paraffin thus obtained is cast into thin cakes, which are slowly heated in an oven, when the most fusible or readily melted part liquefies and runs

away, carrying impurities with it. The residual wax is then melted up and refined by means of animal charcoal or fullers' earth, being thus rendered colourless and odourless. The separated lubricating oils of various grades are purified in the same manner as the kerosene by treatment with acid and alkali.

Vaseline. This product is obtained by concentrating the residuum of ordinary Pennsylvanian or other similar petroleum to the consistency of butter, and dissolving it in petroleum spirit, the solvent being evaporated off after repeated treatment of the solution with animal charcoal.

Characters of the Commercial Products. On redistillation, benzine obtained from the crude petroleum of the United States may be divided into gasoline and a number of other less volatile products, but gasoline itself is sometimes further subdivided into cymogene, rhigolene, and gasoline. Cymogene boils at 32° F., and can therefore be preserved only in a liquid state in a freezing mixture, or under pressure; while rhigolene has a boiling point of 65° F. These products, which have in admixture a specific gravity of ·636, are much used for surgical purposes as local anæsthetics. A highly volatile product, of specific gravity ·625, obtained from gasoline, has long been employed for the same purpose in admixture with sulphuric ether. The generic term of *petroleum ether* is applied to the product in question (not the mixture), but various other descriptions of petroleum ether of higher specific gravity and lower volatility (or higher boiling point) are made in this country. Gasoline, the specific gravity of which usually ranges from ·642 to ·648, is used to carburet air, in what are known as *air-gas machines*, for burning as an illuminant, and is also largely employed as fuel in cooking-stoves in the United States. For use in the internal combustion engines of motor-cars, preference has long been given to a petroleum spirit of ·680 specific gravity imported from the United States or manufactured in this country; but it has become difficult to obtain adequate supplies of this product, and within recent years there has been a progressive increase in the specific gravity of the spirit employed for the purpose. Moreover, a large proportion of the benzine now imported comes from the Dutch East Indies, and this product has a lower boiling point in relation to the specific gravity than that of the American spirit, so that the specific gravity has ceased to be a trustworthy guide to the volatility of the product unless the origin of the spirit is also taken into account. The American deodorised naphtha or benzoline of commerce, which has a specific gravity of about ·700, is used for detergent purposes in the process known as *dry-cleaning*, and as a source of light in sponge lamps. Petroleum spirit from Rumanian petroleum is also now an article of commerce in this country.

Refined Oil. The refined oil (kerosene) obtained from the crude petroleum of the United States is of several descriptions, but only two of these—the ordinary American lamp-oil of commerce, known under the brands of Tea Rose, Royal Daylight, etc., and water-white or high test oils, sold under the brands of White Rose, Snowflake, etc.—are imported into this country. The ordinary oil is usually of a pale straw colour, and has a specific gravity of about ·800. Its flash-point is generally not much above the legal limit of 73° F. (Abel test). The higher grade of oil, of which the average crude petroleum yields only about 15 per cent. or 16 per cent., is colourless, or nearly so, and has a specific gravity of about ·79. Its flash-point is over 100° F. (Abel test). There is also manufactured to a small extent a burning oil having a specific gravity of ·825 to ·830 and a flash-point of about 250° F. (Abel test). Of this oil, which is usually known as *mineral colza oil*, about 10 per cent. may be obtained from the crude petroleum.

Russian crude petroleum furnishes parallel products of a somewhat different character. The yield of benzine is usually much lower, and the ordinary kerosene, obtained to the extent of only from 27 per cent. to 40 per cent. of the crude oil, has the comparatively high specific gravity of ·825, and a flash-point of about 85° F. (Abel test). The most important commercial product is the residuum, which, under the name of *astatki*, is very largely employed as liquid fuel.

Kerosene is also imported into Great Britain from Rumania.

Of mineral oils for lubricating purposes an extensive series is imported from the United States and Russia under the names of spindle oil, engine oil, cylinder oil, valve oil, etc., the names indicating the general characters and uses. These oils are of various specific gravities, flash-points, and viscosities, according to the purposes for which they are intended.

Oils for gas-making and other purposes, intermediate in physical characters between the burning oils and the lubricating oils, are also imported.

Methods of Testing. Although, for commercial purposes, many tests are applied to petroleum products in order to ascertain their suitability for the uses to which they are intended to be put, the legal enactments are based solely on the determination of the risk of fire as measured by the temperature at which inflammable vapour is given off by the oil, the test being known as that of *flashing-point* or *flash-point*, and on this basis regulations are made respecting the keeping, carriage, and handling of such crude oils and products as are regarded as dangerous. The early petroleum legislation in the United Kingdom fixed the standard of flash-point at 100° F., the test being performed by heating a sample of the oil in a small open cup placed in a water bath, the arrangement resembling a carpenter's gluepot, and passing a small flame at intervals across the surface of the oil as the temperature rose above 90° F., until a pale-blue flicker or flash was observed. Owing to the unsatisfactory results furnished by this comparatively rough method of testing, the Petroleum Act of 1879 was passed with the object of substituting the "Abel test," devised by the late Sir Frederick Abel, in which a closed cup is used. The Abel testing instrument consists of a cylindrical oil vessel, fitted with a thermometer and provided with a cover, in which there are three openings. These openings are covered and uncovered by means of a slide working in guides, and having corresponding perforations. As the slide is drawn back to open the cup, it automatically tilts a small test lamp, so that the flame of the latter just enters the oil vessel. The oil cup is placed in an air-jacketed space in an outer vessel containing water previously heated, and, in order to ensure uniform results, the test has to be performed in accordance with specific directions relating to the filling of the oil cup, the initial temperature of the water bath, the size of the test flame, and the time occupied in applying this flame. The first application of the flame is made when the oil attains a temperature of 66° F., and the standard flashing-point is fixed at 73° F., this temperature corresponding to the old standard of 100° F. in the open cup. A modification of this apparatus, in which the slide

is moved by clockwork, is used for testing petroleum under the Indian Petroleum Act, the minimum flashing-point for safe oil being fixed at 76° F., with a correction for the effect of variations in atmospheric pressure. In India the application of the test flame is directed to be begun at a relatively earlier stage of the test than in colder countries, with the object of getting rid of the vapour which is liable to be disengaged from the oil in filling the cup in a tropical climate, as this may cause a flash to occur prematurely.

Testing Lubricating Oils. For testing the flash-point of lubricating oils, another modification of the Abel apparatus, known as the Pensky-Martens tester, is largely used. The oil-cup of this instrument is fitted with a stirrer to ensure uniformity in the temperature of the contents of the cup, and the application of the test flame (furnished by coal-gas issuing from a small jet) is effected by means of a rotating vertical rod. The oil-cup is heated to the requisite temperature in a cast-iron air bath surrounded by a brass jacket.

The viscosity of lubricating oils is also tested, for this affords a measure of the relative lubricating values of the oils. The instruments employed in making this test are termed *viscometers*, and their action is usually based upon the principle of determining the time occupied in the outflow of a specified quantity of the oil through a jet or small orifice at a given temperature. The standard instrument in this country is the Redwood viscometer, while on the European continent a somewhat similar form of apparatus, known as the Engler viscometer, is largely used.

The commercial value of paraffin wax is largely governed by the so-called *melting point* (which is really the setting point or solidifying point) of the material. This is determined by melting a small quantity in a test tube and stirring it with a sensitive thermometer while the tube and its contents are allowed to cool slowly in the air until a point is reached at which the cooling is arrested by the heat given out by the solidifying paraffin, and the mercurial column remains stationary for a short time. The temperature recorded by the thermometer when this occurs is the melting point.

Transport. Refined oil (kerosene) is chiefly transported in bulk in tank steamships, tank barges, tank railway waggons, similar to those already referred to as being employed in the carriage of crude petroleum, and tank road waggons, the aim of modern practice being to cheapen the cost of transport by keeping the oil in bulk from the time it leaves the refinery until it reaches the lamp in which it is burned. The use of the 40-gallon wooden barrels in which this product was at one time so largely distributed has, accordingly, been almost entirely superseded, but "cases," which are wooden boxes, each holding two tin cans of 4-gal. capacity, are still largely employed for sending the oil into sparsely populated countries, especially in the tropics.

At the present time the Atlantic petroleum steamship fleet is a large one, and some of the vessels are of great capacity. The engines and boilers are sometimes placed amidships and sometimes at the after end. The tanks are formed by the skin of the ship, a decking, and a series of transverse bulkheads, with a central fore-and-aft bulkhead, and they are isolated from the stokehold and engine-room by a double bulkhead or coffer-dam, two of these being required when the engines are amidships, and the screw-shaft being then carried through an oil-tight tunnel. The most important fundamental principle of construction lies in the provision of expansion trunks, extending upwards from the top of the tanks, by means of which the contraction and expansion of the oil under changes of temperature are allowed for, and the tanks always remain full. If it were not for this arrangement the tanks would be liable to overflow or to become partially empty, when the oil would be liable to be set in oscillation and the safety of the ship would be imperilled. The oil is delivered into these steamships by pipe-lines, and is discharged at the rate of hundreds of tons per hour by the vessel's powerful pumps.

Lubricating oils are now very largely shipped from the United States in bulk, and wholly so from Russia. The gas-oil used by gas companies in the manufacture of carburetted water-gas, and in the enriching of coal-gas, is also shipped in bulk.

Paraffin scale for candle-making is transported in barrels, the material being frequently run into the packages in a melted state; and paraffin wax is packed in cases.

Under the bylaws of the Thames Conservancy, petroleum spirit, now almost entirely imported in bulk, is landed at Thames Haven, and is brought up the river in licensed tank barges.

Scottish and Other Oil Shales. The bituminous shales occurring in Scotland (Linlithgow and Midlothian), France (Autun), New South Wales, New Zealand, Nova Scotia, Servia, and elsewhere, yield on destructive distillation, besides ammonia, a series of commercial products, including burning oil, lubricating oils, and solid paraffin, resembling those obtained from crude petroleum. The Scottish shales usually give from 18 gal. to 30 gal. of crude oil to the ton, and in some cases as much as 60 lb. to 70 lb. of sulphate of ammonia. A rich description of shale is mined in New South Wales, which furnishes over 100 gal. of oil to the ton, and some of the New Zealand shale is remarkable for the very large proportion of solid paraffin obtainable from the products of distillation.

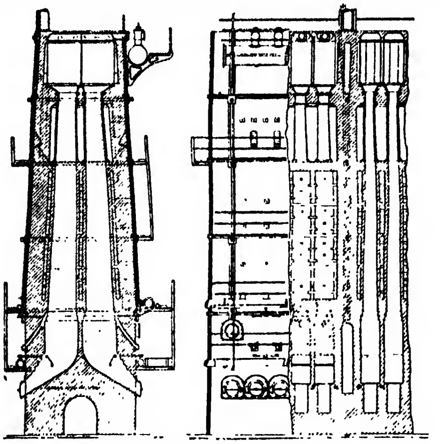
Scottish Shale Oil Industry. The industry has suffered severely from the competition of imported petroleum products, but adversity has been met in a manner deserving of the highest praise, remarkable improvements in plant having been made, and economies effected in working costs. In this connection it should be pointed out that in distilling shale there is an additional source of profit in the ammonia obtained with the oil, and that of the most valuable of the oil products – namely, the solid paraffin—shale oil usually gives a comparatively large yield.

Oil shale is mined similarly to coal, is screened at the mine, and on reaching the works is broken by machinery into flat pieces about six inches square.

Shale Retorts. Horizontal retorts, similar to those used in coal-gas manufacture, were at first adopted for the distillation of the shale, but at an early date these were replaced by vertical retorts, and steam was injected into the retorts to carry off the oil vapours. Distillation under reduced pressure was subsequently introduced, and the spent shale was utilised as fuel for heating the retorts. The use of steam increased the yield of oil by 20 per cent., and by subjecting the shale to a higher temperature in the presence of steam after the oil had been driven off at a moderate heat, a much larger proportion of the nitrogen was obtained in the form of ammonia.

Various improvements in shale retorts were made from time to time by Young, Henderson, Beilby, Fyfe, and others, with the objects of diminishing the cost of working and increasing the yield of oil

and ammonia. The retorts at present in use, of which one type is shown in 2, hold about 30 cwt. and are about 28 ft. in height; they consist of an upper portion of cast iron, surmounted by a hopper,



2. SHALE OIL RETORTS

and a lower portion of firebrick. They are set in benches in a combustion chamber, and are heated through the agency of a gas-producer. The upper part is heated to dull redness, and the lower to a bright, red heat.

Retorting. The process of distillation is a continuous one, the spent shale being gradually withdrawn from the base of the retort, and a corresponding quantity of fresh shale entering from the hopper at the top. About twenty-four hours is occupied in the passage of the shale through the retort.

The vapours issuing from the distilling charge, amounting to about 3,000 cubic ft. per ton of shale, pass from the top of the retort into a vertical tube condenser, where the oil and ammoniacal liquor are separated. The uncondensed gas may be used for lighting or heating, or the very volatile liquid hydrocarbons which it contains may be obtained by passing it through a scrubber, and the residual gas, which then has no illuminating power, is utilised as fuel.

The ammoniacal liquor from the condenser is distilled, and the liberated ammonia is brought into contact with sulphuric acid, with which it combines to form commercial sulphate of ammonia.

Shale Oil Refining. The crude shale oil, which is of a dark green colour, is subjected to a continuous process of fractional distillation substantially similar to that already described as applied to crude petroleum, and is thus separated into light and heavy oils and paraffin wax, steam being passed into the stills in order to facilitate the operation and prevent injury to the products by overheating. The light oil furnishes a small proportion of naphtha on redistillation, after treatment with acid and alkali, the remainder of the light oil consisting of the burning oil, or paraffin oil, used in lamps. The heavy oil is cooled, so as to cause the solid hydrocarbons to crystallise out, and is then passed through filter-presses, which separate the paraffin from the oil.

Paraffin Refining. The crude paraffin was formerly refined by dissolving it in the naphtha obtained from the light oil distillate, allowing it to crystallise out in shallow trays, and pressing the cakes thus obtained. This method of treatment has, however, been superseded by the "sweating" process, in which the paraffin is pumped, in a melted state, into shallow trays, supported above transverse heating-pipes in a closed chamber or stove. Each tray is fitted with a perforated strainer, of about 16 apertures to the inch, which is covered to the depth of about half an inch with cold water, the melted paraffin floating on this layer of water above the strainer. When the paraffin has solidified, the water is drawn off, and the cake of paraffin rests on the strainer. Steam is then passed through the heating-pipes, and the temperature of the stove is slowly and cautiously raised to the point at which sweating takes place. The effect of the heat so applied is to cause the softer and more fusible portion of the paraffin to melt and drain through the strainer, carrying with it the impurities, and this portion is drawn off. The hard paraffin remaining on the strainer is then melted by further raising the temperature of the stove, drawn off from the tray, decolorised by agitation for some time with animal charcoal and cast into cakes for sale to the candle makers.

Yield of Products. The heavy oil from which the paraffin has been separated in the filter presses yields, by further refining, a series of lubricating oils of various specific gravities, flash-points, and viscosities. The proportions of the various commercial products yielded by Scottish shale vary with the nature of the shale and the process of manufacture, but may be taken as ordinarily being about 3 per cent. to 6 per cent. of naphtha (including gasoline), 39 per cent. of burning oil (including gas oil), 18 per cent, of lubricating oils, and 10 per cent. of paraffin (refined and semi-refined), the loss being thus no less than 30 per cent. The loss is very large compared with that sustained in the refining of crude petroleum, and indicates the disadvantage under which the shale-oil refiner works. Before he is in the same position as the petroleum refiner he has to mine and break the shale and subject it to destructive distillation, and his crude oil is far more difficult to refine than the raw material with which the petroleum refiner usually has to deal. Against the extra expenditure which this entails the profit on the sulphate of ammonia is to be set, and it is this, coupled with the large yield of the valuable product, paraffin, which has enabled the shale-oil industry effectively to meet the competition of petroleum.

French Shale Oil Industry. In France the distillation of shale was begun as far back as 1830, and the French industry is, therefore, much older than the Scottish, though it has made less progress, and is of smaller commercial importance. The chief centres of the industry are at Autun, and Buxière-les-Mines. The shale yields only about 17½ gal. of oil to the ton, and 5 per cent. to 7 per cent. of sulphate of ammonia. The oil is fractionated and refined in the same manner as Scottish shale oil, but is less easily converted into commercial products of satisfactory quality. It yields about 3·5 per cent. of naphtha, 19 per cent. of burning oil, 23 per cent. of gas oil, 8 per cent. of pale oil, 17 per cent. to 18 per cent. of lubricating oils, and 2·7 per cent. of refined paraffin. The industry has declined since the removal of the heavy import duties on crude petroleum, which formerly protected it.

Australian and New Zealand Shale Oil. In New South Wales, a so-called "kerosene shale," resembling cannel coal, has been mined and distilled since 1865. Some of this mineral yields over 100 gal. of oil to the ton. The retorting has latterly been carried on near Torbane, west of the Blue Mountains, and about 130 miles from Sydney,

the crude oil being transported by rail in tank waggons to a refinery at Hartley Vale. Recently an English company has been formed to develop the industry on a large scale, and plant for retorting and refining, capable of dealing with a large output of shale, is in course of erection.

Bituminous shales occur in the upper portions of the coal measures of New Zealand, and that which is found at Orepuki yields a crude oil containing a remarkably large proportion of solid hydrocarbons.

The Brown Coal-tar Industry. In Prussian Saxony, the destructive distillation of lignite, and conversion of the tar obtained into commercial products resembling those yielded by shale oil, constitutes an industry of local importance. The tar is fractionally distilled under reduced pressure, with the object of preventing the decomposition which would otherwise occur, and in this manner from 8 per cent. to 30 per cent. of light oil, 15 per cent. to 30 per cent. of lubricating oils, and 1·5 per cent. to 12 per cent. of paraffin, are made from it. In other respects the process adopted resembles that already described as applied in the refining of shale oil.

Kimmeridge Shale. The extensive deposits of shale in Dorsetshire admit of being mined at a low cost, and give a satisfactory yield of crude oil, but the refining of this oil presents exceptional difficulties which have hitherto stood in the way of its utilisation.

Uses of Petroleum. Crude petroleum has from the earliest times been employed as a curative agent, especially in cutaneous affections of men and animals, in the treatment of wounds, and for the relief of strains and rheumatism. For pharmaceutical purposes crude petroleum is no longer in general use by civilised communities, but the well-known product vaseline is very largely employed, both alone, and as a means of applying medicinal substances, where local action, rather than absorption, is desired, its physical and chemical characters rendering it superior to an animal fat for such a purpose.

Vaseline is also largely used as a protective coating for surfaces liable to injury from damp and exposure to the air; and it is an important ingredient of the smokeless explosive, cordite.

In surgery the more volatile products of petroleum have been found valuable as anæsthetics, especially in producing local insensibility by the cold resulting from rapid evaporation.

Petroleum Lighting and Heating. As a source of light and heat, petroleum and natural gas have been favourably known for ages, and at the beginning of the second half of the past century the petroleum or paraffin lamp and the paraffin candle became recognised as among the necessaries of civilised life. Indeed, it may be said that no modern article of commerce has done as much as refined petroleum to promote comfort and extend man's capacity for leading a fruitful life, for it has encouraged domesticity and has largely increased the number of hours available for study. Recognising this, some have even gone as far as to say that the progress of a nation in civilisation may be measured by the consumption of petroleum per head of population.

The illuminating agent supplied by the gas companies is often largely composed of carburetted water-gas, in the manufacture of which great quantities of petroleum are used. In some of the principal cities of the United States the latter gas has, in fact, entirely replaced coal-gas. Volatile petroleum products are also used in enriching coal-gas, so as to bring its illuminating power up to the required standard.

Petroleum - driven Vehicles. It is scarcely necessary to mention the highly important part which petroleum spirit is now playing in revolutionising the means of locomotion through the medium of public service vehicles (motor omnibuses) in the great cities, and private self-propelled carriages throughout the country.

The advent of the private motor-car is directing renewed attention to the splendid high-roads of this country, and is reviving the ancient glories of wayside hostelries, with great advantage to the mental and physical condition of those who are fortunate enough to be able to employ, wisely, temperately, and judiciously, this means of travelling in place of the railway.

It is well known that the source of power in that modern addition to the belligerent marine, the submarine, is petroleum spirit, these vessels being propelled by internal-combustion motors whilst on the surface of the water, and receiving their stores of the electricity which drives them beneath the surface from the same source.

As liquid fuel for use in steam raising for power purposes, both on land and at sea, as well as in metallurgical and other work, petroleum has now taken a most important place as a heating agent of far higher efficiency than even the best steam coal.

Lubricating Oils. The lubricating properties of petroleum were recognised at a very early date, and one of the first applications of the more viscous descriptions of this product found on or near the surface of the ground was in the greasing of the wooden axles of primitive carts. The manufacture of lubricating oils from petroleum has long since been brought to a high degree of excellence, and such oils have now very largely replaced the animal and vegetable oils and fats previously employed for the purpose.

There is a large consumption of the softer and more fusible kinds of paraffin for rendering wooden matches readily inflammable. Paraffin also is or has been used in waterproofing match-heads; in strengthening and waterproofing woollen fabrics; as a "resist" in dyeing, the parts of the fabric coated with it rejecting the dye; for lining brewers' vats and beer barrels; for preserving stone, wood, eggs, meat, fruit, and flowers; for glazing, protecting, and waterproofing paper; as an adjunct to starch for glazing linen; as an auxiliary to soap for laundry work; as an electrical-insulator; as a substitute for fat for absorbing perfume from flower petals; and as an easily-moulded material in making ship models.

Petroleum in Soap Manufacture. The detergent properties of petroleum account for its extensive introduction into household soaps. Petroleum is also the active ingredient of certain insecticides. Petroleum spirit is largely employed in the process known as dry-cleaning; in the extraction of grease from leather; as a solvent for various purposes, and especially, in a carefully prepared form, as a substitute for oil of turpentine for use in making paints and varnishes.

Among other uses of petroleum may be mentioned those of ore-concentration, and the removal of fusel oil from crude molasses spirit.

In the form of "westrumite," and other preparations, petroleum has been successfully employed as a dressing for road surfaces to prevent disintegration and the raising of dust, its slower rate of evaporation rendering its action more lasting than that of water.

Many patents have been granted for the solidification of petroleum, chiefly with a view to the use of the product as a fuel, either alone, or in admixture with coal-dust or other combustible substances, in the form of briquettes. Among the solidifying agents which have been specified for this use are resin soap, extract of quillaia bark, lichen extract, fish glue, casein, and glue (with formalin as a hardening agent).

A product known as soluble petroleum is prepared by partially saponifying resin previously dissolved in the oil, or by blowing air through a mixture of resin oil and caustic soda solution, and adding to the jelly-like mass thus obtained an aqueous solution of a fatty oil soap and mineral lubricating oil. The product is intended to be employed, in admixture with water, as a lubricant, especially for tools used in boring and cutting metals, and is stated to have given excellent results.

Petroleum as an Illuminating Agent. Petroleum or paraffin lamps are usually fitted either with a single or duplex flat-wick burner or with an Argand burner, the former being more largely used in Great Britain and America, while the Argand, or annular wick type, is more popular on the Continent. The latter type of lamp is provided with a central air-supply channel, sometimes extending down through the oil-container to the base, and a disc or button is usually fixed at a short distance above the top of the wick-tube, so that the upward current of air induced by the heated chimney is deflected outwards and caused to impinge on the inner surface of the flame. Air is also supplied separately to the outer surface. Burners of the duplex type are usually fitted with an extinguisher, which is sometimes arranged to come into action automatically in the event of the lamp being overturned.

In one form of lamp the petroleum is vaporised and the vapour is conducted into an inverted Argand burner; in another a mixture of petroleum vapour and air, burning with a non-luminous flame, is employed to heat a Welsbach incandescent mantle.

A given amount of light was formerly obtainable from mineral oil at a much lower cost than from gas, but the general use of the incandescent mantle has so largely added to the efficiency of the latter illuminating agent that the comparative positions in respect of cost have been reversed, unless a mantle be also used with oil.

Petroleum Lamps. The subject of accidents with mineral oil lamps has in past years attracted considerable attention, and it has been contended that the minimum legal flash-point of 73° F. should be raised to 100° F. in the interest of public safety.

Formerly all lamp accidents were described in the newspapers as explosions, but investigation has shown that at least 75 per cent. or 80 per cent. of them have been due to the overturning or dropping of the lamp or to its fracture from some other cause. In fact, with a properly constructed lamp, and with ordinary care and intelligence in its use, an explosion ought never to occur.

In choosing a table lamp the purchaser should note whether it has sufficient stability, or, in other words, whether it is easily upset or not. If the lamp has the usual pedestal its attachment to the oil container should be substantial. The oil container should be of sufficient strength to withstand a fall from the height of a table on to a bare wooden floor without being broken or allowing the oil to escape, and, notwithstanding the merits of glass, it is safer to have a well-made container of metal. The burner should be securely attached to the oil container, and there should be no opening in it by which flame can communicate with the interior of the oil container. The burner should admit of being taken to pieces for cleaning, and it should be fitted with a good, substantial chimney gallery.

The Use of a Lamp. In the care and use of the lamp, the following should be borne in mind:

1. The wick should quite fill the wick-tube without having to be squeezed into it.
2. Before using, the wick should be dried at the fire, and then immediately soaked with oil.
3. Wicks should be in lengths of not more than 10 in., and should always reach the bottom of the oil container.
4. It is well to change the wick after two months' use.
5. See that the chimney of the lamp fits properly, and is held sufficiently tight so as not to fall off when the lamp is used.
6. When a new wick or chimney is required, it is always advisable to take the burner to the shop so that it may be properly fitted.
7. The burner should be taken to pieces and thoroughly cleansed at least once a month, and all burnt pieces of wick, dead flies, etc., should be carefully removed.
8. Never refill the lamp when it is alight or near a fire or other light.
9. After filling, see that the burner is properly fixed on, and if there is a side filling-hole, be careful to screw in the plug.
10. Before lighting, remove the burnt crust of the wick.
11. Be careful not to spill oil in filling, and if any is spilt on the lamp, wipe it off.
12. Before lighting, see that the slit in the cone of the burner is exactly over the wick-tube, so that the flame will not touch the metal.
13. When first lit, the wick should be partially turned down, and then gradually raised, but not so as to smoke. When the edge of the flame is orange coloured the lamp is not burning properly, and the burner should be examined.
14. Do not continue to burn the oil until it is completely exhausted. It is best to keep the lamp well filled.
15. Lamps which have no extinguisher should be put out thus: The wick should be turned down until there is only a small flickering flame, care being taken not to turn down so far that the wick falls into the oil container. The small flame may be extinguished by placing a piece of flat tin or card on the top of the chimney or by blowing across the top of the chimney. Never blow down the chimney.
16. Never use a lamp which is broken or in any way out of order, or a chimney which is cracked. If any part comes loose, or is out of shape or defective, it should be taken to a lamp shop to be repaired.
17. Always place the lamp in a secure place, and on a level surface, and never on a rickety table, or in any position where it could be easily upset. Hanging lamps should not be put on insecure nails in the wall.
18. Table lamps should not be carried about more than is necessary, and nothing else should be carried at the same time. Heavy lamps should be carried in both hands. The greater number of lamp accidents have been caused by dropping a lamp while it was being carried.
19. Lamps should not be turned down except for the purpose of putting them out. If turned low, the oil is liable to be unduly heated.
20. Should a person's clothes become ignited, the flames should be smothered with a hearth-rug, blanket, woollen tablecloth, or wet towel.
21. Never pour oil on a fire.

Outdoor Lighting. Various special kinds of lamps are used in the open air. For use on ships and on the rolling-stock of railways it is necessary that the lamps shall be constructed so that the air supply is not affected by the force of the wind, and that water cannot gain entrance. In the lighting of large areas during building and engineering operations, extensive use is made of lamps of the Lucigen and Wells type, in which the oil is forced up from a closed receiver by compressed air and sprayed through a heated burner, a light of 2,000 to 2,500 candle-power being given. In the Kitson lamp for street lighting compressed air is also used to raise the oil to the burner, where it is vaporised, and by means of the flame thus obtained a large mantle is heated to incandescence. A light of 1,000-candle power is thus produced at the very low cost of 1d. per 1,000 candle-hours. This represents the highest economy hitherto obtained in the use of mineral oil, and compares with 2¼d. for the incandescent table lamp, or 7¼d. for the duplex lamp. The same amount of light obtained from coal-gas on the pressure incandescence system (with

which the Kitson system of oil burning is fairly comparable) probably costs, on the average, about 1¾d.; with the ordinary incandescent mantle as used in dwellings, 2¼d. (the same as oil); or with a fish-tail burner, about 1s. 6d. The comparative cost of incandescence electric light may be put at 1s. 2d.

Air-gas. To some extent in this country, and far more largely in America, air saturated with the vapour of petroleum spirit is employed as an illuminating agent under the name of *air-gas*, and various mechanical devices are employed to effect uniform saturation under varying conditions. The air-gas may be used with ordinary gas-burners, or, after admixture with a further quantity of air, may be burned under a mantle. A portable lamp has been introduced in which the spirit is absorbed by a porous material and gradually vaporised, the heavy vapour flowing by gravitation to the burner and drawing in the air required to produce a non-luminous flame for heating a mantle.

Oil-gas. In order to produce a permanent gas of high illuminating power (50 candles) capable of bearing compression to 10 atmospheres, for use in lighting railway trains, buoys, and lighthouses, a suitable description of petroleum is slowly introduced into a retort maintained at a cherry-red heat.

Carburetted Water-gas. A similar description of oil is also very largely used by the principal gas companies in the manufacture of carburetted water-gas, and as a substitute for cannel coal in enriching coal-gas. In the Lowe system, used in English gasworks, water-gas is formed by blowing steam through incandescent coke or anthracite in a generator. This gas is passed through a superheater, where the oil is added, and the mixture of oil-vapour and water-gas is then taken through another superheater of large size in which the hydrocarbons are converted into permanent gas.

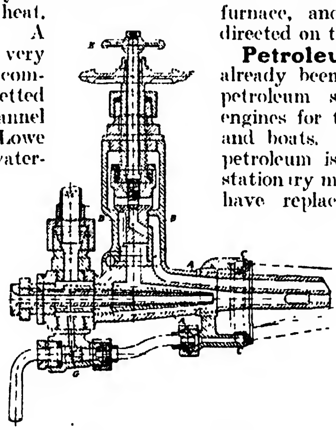
Natural Gas. Certain portions of the petroliferous territories of the United States yields natural gas of an estimated aggregate annual value of about 36,000,000 dollars, and this gas is used for lighting and heating, as well as in the manufacture of lamp-black. The gas may usually be burned with an Argand or fish-tail burner, but the best results are obtained with a mantle. For some time, natural gas was used to light the railway and town at Heathfield, in Sussex.

Liquid Fuel. Crude petroleum is largely used in the oil-fields, for steam raising, and in refineries, as a means of heating the stills; but the presence of very volatile constituents is a source of risk in storage and handling. Accordingly, either petroleum residuum, which remains in the stills after the separation of the kerosene from such crude oil as that of the Russian oil-fields, or a suitable distillate, with a specified minimum flash-point, is employed on steamships and locomotives, as well as in most industrial establishments where liquid fuel has taken the place of coal. In the British mercantile marine the minimum flash-point is 150° F., but for use in the Navy, liquid fuel is required to have a flash-point of 200° F. It is also needful that the oil should bear exposure to a low temperature, say 32° F., without solidifying.

On the Caspian Sea, and on the railways of Southern Russia, petroleum residuum (ostatki) is the sole fuel; and in California the consumption of liquid fuel has reached very large dimensions. It is common knowledge that the British Admiralty have adopted oil fuel as an adjunct to coal in the modern battleships and armoured cruisers.

Oil fuel is also not only largely used in the furnaces of stationary steam boilers, but is giving highly satisfactory results in metallurgical work, glass melting, etc.

The oil is usually burned by spraying or atomising it by means of steam, but in some cases is broken up into small particles by forcing it under high pressure through a small orifice. The Holden burner, employed in this country on the locomotives of the Great Eastern Railway, is shown in 3. The oil is admitted to the interior of the coned body AA through a regulating valve, BB. The annular steam jet D is provided with a central air-passage. CC is an annular chamber to which steam is admitted, and from which it escapes in jets through six small orifices. E and F are wheels by means of which the valves controlling the supply of fuel may be opened or closed. The cock G regulates the supply of steam to CC. The burner is fixed in the front of the furnace, and the intensely hot flame is directed on to a sloping bridge of firebrick.



3. HOLDEN BURNER FOR LIQUID FUEL

Petroleum Engines. Reference has already been made to the extensive use of petroleum spirit in internal-combustion engines for the propulsion of road vehicles and boats. A less volatile description of petroleum is also very largely employed in stationary motors, which in many instances have replaced steam engines and gas engines. In steam engines of moderate dimensions only 12 per cent. of the heat-value of the fuel burned in the boiler furnace appears in the engine as indicated work, whereas, in the internal-combustion engine, the proportion of heat rendered effective is, in many cases, more than double that percentage, and in one type of engine is as high as 37 per cent. The superior economy of the oil engine is therefore very marked. Preference is generally given to those engines in which one explosion occurs for each two revolutions of the crank-shaft. The first forward stroke of the piston draws in the explosive charge of oil or oil-vapour and air, and the return stroke compresses it. During the next forward stroke, the explosion drives the piston, and on the return stroke the products of combustion are discharged from the cylinder. The Priestman, Hornsby-Akroyd, Trusty, Tangye, and Diesel engines may be taken as typical of the principal forms of oil-motors. The Priestman engine is fitted with a spray-producer, as well as a vaporiser, and the charge is ignited by means of an electric spark. In the Hornsby-Akroyd engine, the explosion is effected by injecting the oil into a red-hot chamber, into which heated air is forced by the piston. In the Trusty engine, the oil is vaporised and the charge is fired by means of an igniting-tube maintained at a red heat. The Tangye engine also has a vaporiser and an ignition-tube. In the Diesel engine, the air admitted to the cylinder is heated, by very high compression, to such a temperature as to cause the immediate combustion of the injected charge of oil.

PETROLEUM concluded; followed by PAPER-MAKING

SILK HATS & CAP-MAKING

The Manufacture of Silk Hats. Body-making. Finishing. Shaping. The Cutting and Making of Various Shapes of Caps. Straw Hats

SILK HATS

The silk hat was first manufactured in France, and its introduction into England was at first conducted with great secrecy, especial care being taken to prevent anyone seeing the process, except those whom they had undertaken to teach "the art and mystery of silk-hat making." However, at the present time the journeymen silk-hatters of this country are as skilful as any of their foreign rivals, and the English-made hat holds its own in the markets of the world.

The variety of shapes in the crown will not be dealt with, as they alter and change so often, but the various curls and shapes of the brim will occupy a prominent place.

The first article to be made is "proof," which is composed of best orange shellac (2 parts), button shellac (1 part), let down by ammonia (½ lb., to every 8 lb. of shellac).

The Foundation of the Hat. The foundation, or body, of the hat is made from calico of different strengths dipped in the "proof" and stretched on frames. First of all we take the brim, which, being the strongest, takes the longest to dry. After the "proof" has been thoroughly cooled, take a frame about 5 ft. by 3 ft. 6 in. along the woodwork of which are a number of nails with large heads and the points protruding on the reverse side about 1½ in., with 5 in. between each nail. Then put the calico, No. 10 or D, in the proof and thoroughly saturate it, taking care in every instance that all parts have absorbed some.

1. FITTING THE BRIM

It is not absolutely necessary that this should be so heavily "charged" with proof, so draw it through the hand. Stretch it on the frame and prepare a stronger calico "twill." This must be charged with proof more than the previous one; in fact, it should be left as full as possible without running. Stretch it on the top of the fold already on the frame, taking care to squeeze both together with finger and thumb at every nail. Then rub with the flat hand, so that the proof of one will adhere to the fold of the other, taking care to begin at the centre and work outwards. The reason for this is to prevent any air between the two "plys," which would prevent their adhesion. As this is an important factor in the manufacture of a good sound brim, special care should be exercised. These two plys are followed by other two, put on in the same manner, the frame to be turned top to bottom after each "ply" is put on to prevent the proof from running to the bottom of the frame if kept in one position too long. Now we are ready for the drying process. Heat plays an important part in the making of the body, yet, while it should be dried quickly, it should not be scorched, for a scorched body never wears well. Therefore the best plan is to dry in a hot stove, but away from the fire that heats it. The crown is then dipped in a similar way, but only one ply is put on the frame.

The Block. The block is made from wood and shaped according to the fashion; some "bell" more than others, whilst some are called taper or straight crowns. The block is made in five pieces, the two largest being for front and back of hat, whilst one is placed in position for each side and the whole is fitted tightly in the hat by a centre piece, graduating from tip to head part.

Take a strip of calico about 8 in. deep and measure twice across the length of the block and once across the width; cut, and fasten the ends together by laying one about ¼ in. or $\frac{3}{16}$ in. over the other and running a warm iron over them. Do not have the iron very hot or it will harden the seam. Place the front and back pieces of the block inside the foundation, allowing ⅜ in. over tip; put in the two side pieces. It will be seen that the "foundation" appears too small, but a gradual warming will allow both the sides and centre piece to be put in. Round two sides of the centre piece put a piece of brim stuff to make the hat a little larger. This "packing" is to allow for a shell which is used at a later stage.

Stretching the Tip. For the next calico required it is necessary to dip a piece in spirit proof, which is best orange shellac dissolved in wood naphtha and called varnish. Having dipped the calico in the varnish and dried

it, cut it into strips of about ½ in. and place ¼ in. on the side crown from the tip, fasten with a warm iron and then iron the other ¼ in. on the tip of the block. Cut level all round. Take another piece of foundation and fasten on the edge of the tip, stretching by warming it, then cut round with scissors. It is necessary to *stretch* the tip, for, if allowed to be fastened slack, it will sink, and to prevent that the tip is stretched to its utmost capacity by warming it and then fastening it to the edges left over from the foundation.

A large mug or tin containing waterproof placed on the back of the bench is necessary, also a brush after the same pattern as a large paint-brush. With the brush apply a coat of proof to the tip and stretch a piece of plain calico across as in the manner described before, and again "proof" it, to make it adhere to the previous portion of the tip and form one solid substance. Take another piece of the calico, which has been dipped in spirit, about 1¼ in. wide, and iron it round the tip in the same manner as the previous one, placing about ¾ in. on the side crown and the rest on the tip.

Fixing the Brim. Take a brim, size 13 in. by 12 in., place it flat on the bench, and arrange the head part of the block in the centre and mark with a knife—or anything with a point—round by the block. Do not cut, but simply mark. With a pair of scissors cut out the centre, allowing about ⅓ in. inside the mark. A wooden frame, called a sunk frame, because the wood is hollowed out to allow the block to fit inside, is now required, the right depth being got by placing pieces of wood underneath the block and allowing ⅛ in. for the thickness of the brim. With a hot iron thoroughly soften the portion inside the mark already made, and then smartly pull over the tip of the block as far as possible. With an iron dummy press it as close to the frame as it can be got, making sure to have some portion of the brim up the side crown of the hat, which must be ironed together a little portion at a time, and followed immediately by the dummy being pressed on the portion ironed. Sides should be done first, then back and front [1]. With a knife cut or pare away a portion of the brim which now adheres to the side crown, taking care not to cut the other portion of the brim, but "paring" it gradually thinner towards the top so that it will not appear thick and bulky.

Take the centre of brim, already cut out, and split the four folds apart; cut two pieces, 2 in. by 1 in., from one of them and iron one on front and the other on the back, ⅝ in. on brim and ⅜ in. on side crown. Cover that piece with a larger one ironed on in the same manner. Iron a spirit "robbin" round the band of the hat, the same width as the previous one, to fasten the brim and side crown more firmly. See the hat is the exact depth; take it out of frame, and cut away the corners of the brim.

With the brush apply a coat of proof to the side crown, taking care not to miss any portion of it; then take a piece of fine muslin about 8 in. wide, beginning at the centre of side with the body seam on the right hand, and pull it round whilst the proof is wet so that the calico will adhere to it. When covered, cut off, take up the end first laid and lay the left side of seam over right; with scissors cut the calico over the tip with the exception of ¼ in., which must be ironed over. The remaining portion of the calico must be put on the tip—after it has been proofed—in the same manner as the previous one; then carefully cut off all corners and apply another coat of proof to all parts of the body, the brim included, and place in stove to dry. Again "proof" it whilst warm; let it cool and then pull block out. Another coat of proof must now be applied, and allowed to dry without the block being in the body.

The Ironing Process. It is now ready for the ironing or smoothing process, for up to the present it presents a rough appearance. First cut away closely with a knife the foundation from underneath the brim; place inside a shell or felt body (self colour), making sure that it fits the tip closely, and put in the back and front pieces of the block. Next fit the side and centre pieces, neither of which will go into the bottom at first, but after an application of gum, powdered in a rag, and a slight application of vegetable wax, the front part can be ironed over until quite smooth with a clean hot iron, followed immediately with a cool iron dummy to set the heated part. Knock the side pieces a little further down and repeat the operation to the back of the body, when the block will easily go in with the exception of the packing pieces, which are not needed now that the shell is in the body. The remaining portions of the body are now ironed, including tip, making sure that all the seams are pressed down, until it has a smooth, level surface; then let it cool, tip downwards.

Next get a brim frame which differs from the one previously mentioned, as it has no portion cut away for block, but has two pegs fitted in on which is placed a brow the size of the hat, and a piece of felt covering the whole frame. Iron the underneath of the brim on a plate fixed in the bench and shaped to the oval of the hat; then immediately place it on the frame, iron it well, and again repeat the operation on the underneath, following it with the cool iron dummy, both on the underneath and also on the top side of brim when on the frame. Iron first one side then the other, followed in order by back and front, making four distinct ironings for the brim. When well ironed it is ready to be varnished before being handed over to the finisher, whose work it is to place the silk on the body.

Finishing. The tools required for the finishing process are these: Irons (1 pair), dummies, 1 concave iron, 1 flat iron, 1 concave wood, 1 flat wood, wire cards (1 tip, 1 side), brushes (1 hard, 1 soft), velures (1 rough, 1 velvet), scissors (1 seam, 1 crooked, 1 ordinary), sponge, stirrup, woollen patch, half block, tip block, brim frame.

Finishing is the art of sticking and retaining the bright colour of the plush. The body, after it has left the bodymaker, receives two thin coats of varnish. The plush is stuck to the body

by means of cold water sponged on the plush, then a warm iron being lightly passed over, and thus a steam is created. This steam enables the plush to stick to the body. The finisher fits the cover on the body the reverse side up; then he measures and marks with chalk the exact line where the seam must be cut. The selvedge side will be on the right-hand side. Mark ½ in. from selvedge, then pass left-hand side over, and mark to correspond. Take cover off and apply a coat of proof on back of plush 1 in. wide over where the seam has to be cut. This stiffens the plush, and will stop it from threading.


2. CURLING THE BRIM

When the proof is dry, take cover in left hand and brush back the nap on the top of the seam; place cover on bench, and apply water on the plush; pass iron over and card back the nap. When well carded, back iron till dry. Then cut with scissors down chalk line and cut selvedge side. Take the plush for brim, damp on the back side, and pull out with fingers wider and shorter. This takes the stiffness out of the plush, and enables it to fall into the band of the hat easier. When dry, pass round outer edge of brim, and stick with cool iron.

Now get brim frame on patch or felt, as used in brimming body, and pull into position the plush with stirrup, care being taken to pull out all the pleats. Then sponge, brush the nap straight, and pass iron over. The brim is usually pulled in at four separate times, first front and back, then sides; when stuck, cut with crooked scissors, care being taken to cut the brim plush ½ in. up the side crown. Now place body on tip block and fit the cover; pass sponge over, and stick top of seam first; when seam has been securely fixed pass tip card over the stitching.


3. HALF-BLOCKING

Sticking the Cover. Stick the tip in position, care being exercised to have all the stitching on tip; do not allow it to drop on the side crown. The nap will then be across the tip from left to right. This must now be carded round to the centre. Damp the plush with sponge, pass warm iron over, and card the nap round while the steam is rising. Again apply water, iron, and card, and the nap will now be in position round the tip.

Place hat on half block (which must be covered with three or four layers of felt), stick the back of hat first, working towards the seam. See that the right-hand side of seam is well stuck.

Bring the seam together, and stick about 1 in. at a time. Brush the nap back to its right position over the seam, and stick remainder of hat; brush well, apply a coat of cold water, and card the nap straight. Water the tip, and bring nap well round to the centre. When dry, brush the glaze, and the plush will now have a dull appearance. For half-blocking, use a warm iron and go round the hat twice; the first time will bring the colour back, and the second time get the hat round [3]. When half blocked place a paper cap on side crown. To cover the underside with merino, apply a coat of varnish, and brush the merino on while wet. Cut merino ½ in. from band, and stick it down side crown; run iron on the top side on brim frame, and the hat is finished.

There are four points to be remembered: (1) when the hat has been warmed with iron, dummy till cold; (2) plush to be well stuck on body; (3) seam and stitching to be pressed well down; (4) the bright colour.

Shaping. The hat is now ready for the shaper, whose duty it is to make a curl and set the hat to its proper shape. This branch has been justly called the "artistic branch," for the appearance of the hat depends to a great extent upon the shaper. A variety of curls and sets are dealt with by the shaper, which, more or less, lends to the attractiveness of the hat. Space, however, forbids us to deal with more than the principal shapes, for the others are but a distinguishing feature, while the workmanship is on similar lines, except in detail as to the size, etc., of curl or set. We will deal with a ½-in. roll, which is the common size of a curl.

First place the hat tip to plank, with the front facing you; then get the centre by placing finger and marking plush on top side of brim; turn the hat round, and perform the same operation with the back. Then place the hat brim to plank, with the centre marks exactly level from left to right. Warm the brim with the iron until it is just bendable, run flat plough over the warm part; then, with a piece of plush between thumb and first finger of left hand, pinch the edge of brim upwards, beginning about ½ in. from the mark on right hand, and finishing about the same distance from the left-hand mark.

The machine or roll brass is now used by running it along the brim and gradually turning it over to the required size [2]. Great care must be exercised in order to ensure a very even and symmetrical curl, and the brass curler must be kept flat along the plank, so that the curl can fit perfectly in the groove. An even and perfect curl is largest in the centre, tapering smaller at the shoulders. It is easy to understand that if the same pressure is exerted all along the brim, the result will be a curl one size from beginning to end; but that is not what is required. Therefore, a gradual pressure and release of same, whilst the brass is in motion, obviates

that, and makes the shoulders or ends considerably smaller than the centre. Having made the curl the required size, the brass or machine must be removed, and under the curl is placed a "rope" or "roll pad," whilst the brim is warm and pressed on the "rope" with a grooved plough. This "rope" or pad is made from calico or tissue paper, the former preferred, as it lasts considerably longer. The curl is now really shaped, but to prevent its losing its rotundity it must be ironed along the top edge, which will produce a shiny surface on the merino. After sufficient ironing, the grooved plough again comes into use in pressing and keeping it to the shape of the ropes. When the rope is removed, a perfectly formed curl is the result, but to ease the setting of the hat it is necessary and expedient to *round* the brim. To do this successfully it is imperative that great care should be exercised.

Get a piece of swansdown, about 12 in. by 9 in., and place it on the merino (with tip of crown to plank); then take a sponge and damp about 1 in. wide from the curl; rub over with the iron a few times, when the steam will have sufficiently warmed the brim to make it pliable. With first finger well under curl and thumb on the merino side of brim, pull round, beginning at the farthest point from you. As in curling, so in rounding, the greatest rounding should be in centre, tapering to each end. This will leave the front and back of brim perfectly flat, and, after curling both sides, the *fronts* can be put in. Place hat on tip, with the curls parallel to you, then gently rub the iron along the inch or so of brim that has not yet been touched, until it is bendable; pinch it as in curling, joining the two curls together, get the *front groove*, and work it along until the front is level. Care must be taken to see that the ends of the curls are evenly joined together by the front, and after front and back have been put in the hat is curled, but not quite finished, for you will observe that the edges of the curls are rough.

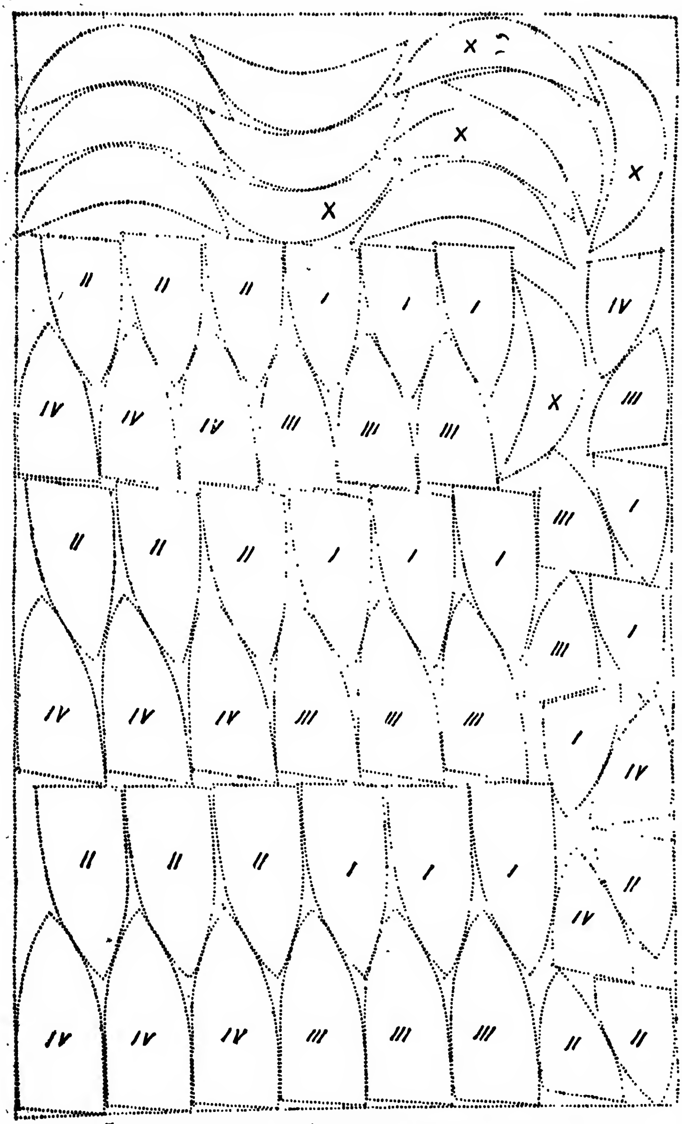
Paring the Curl. To put a perfect finish on the curl it must be pared or chipped. First get a knife—one made from an old razor is best as it lasts longer—which must be shaped and cut out at the front and back, leaving it very small and level. With a paring machine the sides must be cut to make the edges smooth and both curls equal in size. It will be seen that the plush and merino make the curl look ragged and very untidy, but the knife run under or along the edge of the curl will remove the former, whilst the latter may be cleared away by the use of scissors. A piece of fine sandpaper run along the edge of the curl will mend it in appearance. The hat is now placed on a "horse," an arrangement made of wood hollowed out at the top to allow the hat to fit steady, with a "duffer" in it. A duffer is placed in the hat to prevent the heat of the fire from *drawing* the crown of the hat out of shape. It is made from paper or felt and fits close to the head part of the hat. When the hat is warm enough to be bendable, it is ready to be set. Care must be taken not to have it too warm, or it will cockle the brim, making it very uneven.

The shaper places the tip on the plank and begins to make the hat the shape required. When the sides are set to the desired width it will be seen that the back and front look hollow and unlevel, especially in the band which is near the head part. To put it level a cloth has to be placed across the front, water it with a sponge, and then iron it until it is again workable; turn it over, and with a flat plough work the top side of the brim whilst the underneath is placed on a "cheese" or "half frame." It must then be worked with thumb and finger until it is straight, the shoulders are level, and the curl is in perfect symmetry with the brim. It is now ready for the trimmer.

Trimming. The *trimmer* receives the hat after being shaped, along with the following trimmings: Band and binding, tip paper, side paper, silk tip, silk side, leather, tassel, and sticker. First find the centre of brim at back of hat, then measure binding round the edge, and, after cutting it to the size, sew the ends very neatly before sewing it on the brim, the seam to be at back of hat. The binding will then be on the top side of brim with the stitches going through. It must be rubbed on the underneath with a bobbin, to prevent the stitches showing through the binding. Now turn the binding over curl, and sew, or "whip" it to the merino underneath. Then tie the band round the crown of hat, placing bow on left side.


4. LASHING THE LEATHER

Take the tip paper, which is very stiff, place it on the tip on hat, and make an impression round the edge with thumb and finger, which, after cutting, gives the size required, and is ready for the silk tip to be stitched on. The silk side is now sewn round the edge of the tip and the ends "run up" together, the whole forming the lining, but before putting it in the hat the side paper is fixed and made firm with a little paste; this prevents the colour of the body from showing through the silk side. After fixing the lining in, sew it round the top of the paper, which causes it to "bell," through its being cut on the bias, or cross. The leather is to be measured round the inside of the hat and the ends cut so that they will just meet, both being cut on the slant, so that a little more will be cut off the bottom than top. Place the edges of leather together, and with a sticker (a gummed piece of paper) fasten them; also make the tassel into a "bow" and stitch it to the back of the leather. Now place leather in hat, putting the seams of binding and leather in the centre of the back of hat. Get a thin cord (top cord) and fasten it on top of leather with the stitches used for sewing the leather to merino [4]. It prevents the top of the leather from showing



5. CAP-MAKING: ARRANGING MATERIAL ON CLOTH

through the stitches and gives it a more finished appearance.

The hat is now ready to be returned to the shaper, who, with his brim iron, irons the brim and brushes it until the plush presents a smooth and finished appearance. Run down the band with a band peg or thin piece of wood, strip the paper cap, iron the crown, and follow with a velvet velure. Put on the white cap, and the hat is completed.

CAP-MAKING

To-day, cap-making gives employment to thousands of hands, has special factories and machinery, and large sums of money are invested in the industry. But there is no reason why caps should not be made by any person who has a knowledge of producing other articles of wearing apparel.

As a home industry, however, cap-making has largely died out. It has been killed by machinery, skilled factory organisation, and subdivision of labour. All these things tended to make the cloth cap wonderfully cheap, but since the introduction of a much higher class for motoring purposes, and of a greater degree of artistic design in those now worn, prices have risen to so great an extent that a really well-made cloth cap is rated at a price practically equal to that of the best kind of bowler or the cheaper make of silk hat. Still, there appears no reason why cap-making should not be developed as a home industry. It is comparatively simple work.

The ordinary kind of cap is produced from eight three-cornered pieces which, when laid out flat, would form the segments of a circle.

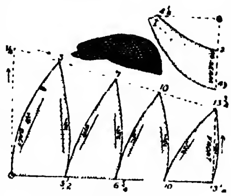
In the factories these pieces are cut from cardboard discs representing the different sizes. Thus, the circumference of the disc for size $6\frac{7}{8}$ would be about 25 in. The actual circumference for a size of $6\frac{7}{8}$ is 22 in., but the extra inches are allowed for the seams. By careful cutting a yard of cloth 54 in. wide would make a dozen golf caps of average sizes.

Getting the "Lay." The usual practice of the cap manufacturer is to purchase a number of pieces of tweed made in the large home-spun check patterns which are now the favourite designs. When these are delivered at his factory the first process is to get what is called "the lay"; that is, to arrange the cloth so that the caps can be made with the least possible waste of material, due regard being paid to the necessity of matching the pattern when the pieces come to be put together.

When this has been done, a pattern is cut out of several thicknesses of cloth by means of a band knife, which will cut through a hundred layers of the material as easily as one. The parts are then ready for the machinists, who stitch the several pieces together, after which the partly made-up cap is passed on to the finishers, who put in the linings—which are cut by the same process—cover the peaks, put strapping on the seams, and complete the work.

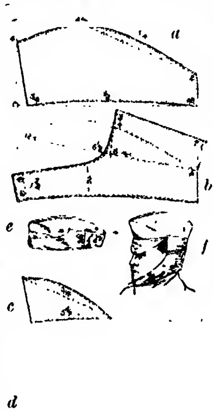
In the making of the caps there are four distinct processes: cutting, machining or sewing,

pressing and finishing. The workers become exceptionally expert in their own particular departments. The cutter can lay out his cloth so that there is no waste, the machinist can join the pieces together with marvellous quickness on the electric power sewing machine, the pressers open the seams and mould the shape on blocks, and the finishers can complete the article with wonderful rapidity. With the exception of the cutters, the hands are women workers, and one expert cutter can easily keep fifty or sixty machinists busy.


6. CLOTH CAP

The term "finishing" includes the process of sewing in the linings and other hand work, and sometimes the finisher does the pressing and blocking. When the cap leaves the hands of the machinist it looks like a cloth bag, but by careful manipulation upon a wooden block, and by the aid of a heavy iron like a tailor's goose, the seams are pressed down and the cloth shaped ready to wear. On an average a cap passes through nine processes and through the hands of as many workers before it is complete.

The rapid growth of the trade would, of course, have been impossible without the sewing machine and the band knife, but especially the first named. A cap factory, in its way, shows some of the best points of modern industrial organisation. The different processes dovetail into each other, and there is no waste of time or energy. The result is that a good, useful cap can be made to sell at a shilling, which fifteen or twenty years ago would have cost five times as much. The employes earn a fair living wage on account of the large quantity they can produce with the aid of machinery, skilful organisation, and careful subdivision of labour. The reason that the cap trade has settled down in London and Leeds is that it is an adjunct to the ready-made clothing trade. The class of labour required is very similar, and in both London and Leeds there is an unlimited supply of skilled machinists. When work is slack in the clothing factories they can work in the cap factories, and vice versâ.



7. THE 'GLENGARRY' CAP

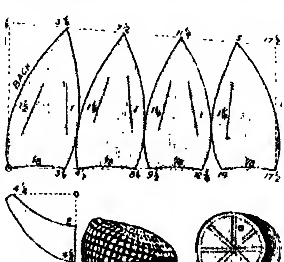
Sizes. It is worthy of note that north of the Humber the caps in demand are of a larger size than in any other parts of the country. The average size throughout Lancashire and Yorkshire and the Northern counties is 6⅞; in the South it is 6¾. The sizes of the caps start at 5 and go up to 7½. After that they are called "out sizes"; 7¼ is considered large, 7⅜ is seldom asked for, whilst 7½ is thought abnormal. A man with a head above that size would have to have his caps specially made. The first size (5) fits a head of 18 in. in circumference, and each additional size means an average increase of $\frac{5}{16}$ in. The medium size (6¾) fits a head circumference of 21 in. A size is obtained by taking the length and breadth of the head, adding them together, and dividing by two. The golf cap is the favourite style for men's wear, but a great variety of shapes are produced, and the different patterns of a large manufacturer will number a couple of hundred.

The variety is caused by the different fashions in women's and children's caps, and a great demand has sprung up recently for women's golf and motoring caps. The characteristic features are, however, retained in the various styles, the chief differences being in respect to size, shape of peak, and other details.

The accompanying diagrams show the method of cutting two of the standard shapes, and also the service cap known as the "Glengarry." Size 7 is taken as a model, and as the figures correspond to those of the ordinary inch tape, modifications both as regards size and style can easily be introduced.

The Golf Cap. The golf cap is cut in ten pieces, eight of which are sections of the upper part of the cap, and the remaining two form the peak.

The accompanying diagram [8] is a reduced model of one of the best shapes of a leading maker. The size can be varied by adding a little to, or taking a little from, the various seams; the inside portion of the peak is cut of the same shape, but rather smaller than the lower diagram. The various parts should be taken from the cloth in much the same way as they are arranged on the diagram, and should be cut exactly on the line, as provision is made for ¼ in. seams at all parts.



8. GOLF CAP

Now baste the various parts together and sew the seams by machine, making the seams ¼ in. wide, and in doing this, care must be taken to get a neat finish at the point where all the sections meet. In order to do this, the best plan is to make up the two sides first, and then seam these together from front to back. Prior to this, however, it will be advantageous to press the seams. Cap-makers have proper blocks for this, the shape varying with each style of cap; much may be done by turning a sleeve-board on its side and using the rounded end. The seams being sewn and pressed open, the peak is made up and stitched, and in order to ensure its being put on in the centre, fold the peak over and make a notch, putting this to the centre seam in front. The peak is lined through with heavy canvas.

The edge of the cap is now turned in, and it is ready for the lining, which is done in

various ways: (1) A lining of silk the same shape as the outside, which is felled round the edges. (2) A leather headband round the bottom, and a silk head lining in the crown after the style of a hat. (3) A leather band and the seams covered with galloon after the manner shown in the sketch, the galloon being stitched on so as to cover the seams and make a neat and light finish.

The top of the cap where all the seams meet is usually covered with a small button made of the same material.

The front is provided with a hook and loop or a glove fastener to make it pouch over in front, and sometimes ventilators are put in the crown, after the style shown in the sketch.

There is room for a good deal of skill in the finish of caps, and this has more to do with the pressing than any other part; the superior shape imparted to those made by high-class firms is due to the extra facilities they have in the way of blocks and so on for the pressing purposes.

We also give another style of cloth cap, with a flatter front and not so full a crown [6]. This is a style of cap very popular in the North of England. Thousands of these are made up in Leeds, where they are produced very cheaply in the way previously described. The lay here given [5] was photographically reduced from one in use at one of the largest factories. It will be seen that no material is wasted, and in order to avoid confusion the various parts are marked in numbers. These lays are prepared in buckram and are perforated; they are then placed on the cloth from which the caps are to be cut, and a pad containing powdered chalk is passed over it, and the outline is marked.

The Glengarry Cap. By way of making this article complete we give diagrams showing how to cut a Glengarry cap with part to turn down over the ears and fasten under the chin [7]. This diagram has no provision made for seams, and the size head it will fit is 7. Figures *a* and *b* represent the side, *c* the peak, and *d* the crown. Two each of these parts are required for the cap, together with peak, lining, and lining for *b*. The peak is cut on the crease. The process of making is much the same as already described, though the peak would be finished in softer style.

We give illustrations of this cap folded up, and also in wear with the ear laps brought down and fastened under the chin [7*e* and 7*f*].

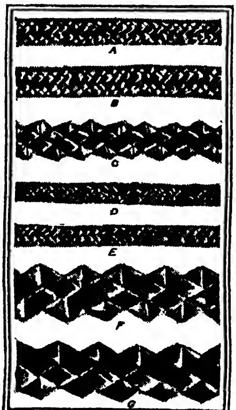
The following table gives the ordinary range of sizes, together with the head measurements to which these sizes correspond:

18½	18⅞	19¼	19⅝	20	20⅜	20⅞	21¼	21⅝	22	22⅜	22¾	23⅛	23⅝	24	24⅜
5⅞	6	6⅛	6¼	6⅜	6½	6⅝	6¾	6⅞	7	7⅛	7¼	7⅜	7½	7⅝	7¾

STRAW HATS

The making of straw hats, especially for women's wear, is one which can be easily carried on at home, as no expensive appliances are needed.

Straw hats are roughly divided into two classes, "block" and "shape" styles. The first have hard crowns and brims, and the shaped styles are usually soft and flexible. The "shape" styles are, as a rule, confined to the various sailor types, and to make them a block is necessary. The straw plait is sewn into a circular mat, and then placed over the block, and by means of a hot iron it is manipulated into the same shape as the block. This forms the crown, and the rim is blocked and pressed in the same fashion. The rim and crown are then sewn together, and the hat is ready to be trimmed and lined.



9. STRAW PLAITS
a. Pedal white *b*. Canton white *c*. Fine rustic white *d*. Tuscan white *e*. Fine pedal white *f*. Coarse rustic white *g*. Coarse rustic black and white

As stated, blocked hats are for the most part factory made, but the shaped styles for women's wear can be easily made at home. The first thing necessary is to get the skeleton, which is made of wire. This can be bought ready-made, or it can be fashioned to suit the individual taste. A plain hat of the sailor pattern can be made with three circles joined together by oblong pieces, all of wire. Upon this skeleton the straw plait is sewn, and when the hat is complete the wires can be removed, or if it is desired they can remain in the hat to enable it to keep its shape. There is a great variety of colours and styles, from the fine and narrow English and French plaits, and what are described as the rustic Japanese, which are the largest and coarsest kinds [9]. It will easily be seen that a hat can be made of a broad plait much more quickly than from a narrow one, and for that reason the broad plaits are much more in favour. The plaits are sold in bundles 12 yd. long, which is sufficient to make a large hat. The price per piece, or bundle, is from 6d. to 6s., according to style and quality. The wire skeleton costs only a few pence [see also MILLINERY, page 5217].

For men's and boys' straw hats the principal shapes are the "Boater," which has a flat top, and a flat brim of varying degrees of width, and is made from both the fine and coarse kinds of plait; the "Trilby," or Alpine style, with indented crown, for which the fine Tuscan or pedal straw is used, and the "Panama" shape, for which the finest plaits are also required. The real Panama is not made from straw, but from a long grass grown in tropical and subtropical countries, and the hat itself is plaited from the grass fibres, considerable time being occupied in the process.

The scale of sizes given for cloth caps will be equally serviceable for the ordinary shapes of straw hats.

Continued

TIN AND ZINC

The Sources, Properties, Recovery, and Industrial Uses of Tin and Zinc. Tin-plates. The Processes of Tinning and Galvanising

Continued from page 5993

TIN

Tin, the symbol of which is Sn, and the atomic weight 117·35, was one of the metals familiar to and used by primitive man. Bronze is an alloy of tin and copper, and bronzes have been recovered from the ruins of ancient Nineveh and other sites which were peopled back in the dawn of recorded history.

Properties of Tin. The colour of metallic tin is silver white, with a lustre that increases with the temperature at which it has been poured. The crystalline structure of tin is the cause of the "cry" of tin—that is, when a piece of tin is bent, the crystals grind against each other, and occasion the peculiar sound so designated. Commercial tin has a specific gravity of 7·5, purer tin being slightly lower. At low temperatures tin is very ductile—its point of maximum ductility being at about the boiling point of water—and can be beaten and rolled into foil, but at 200° C. it is extremely friable and can be powdered. Though ductile, it has little tenacity. Its exact melting point is uncertain, but is about 228° C., its boiling point is between 1,600° and 1,800° C., and at this temperature it burns in the air, thereby forming stannic oxide. Its thermal conductivity is about 150 (silver = 1,000), and its electrical conductivity at 21° C. is slightly over 11 (silver = 100).

Occurrence of Tin. The localities favoured by deposits of tin are not numerous. The mineral never occurs in the native state and only in a few chemical combinations. The most common ore is *cassiterite* or *tinstone*, a dioxide of tin (SnO_2). The tinstone found in Cornwall contains also sulphide of copper, wolfram, pyrites and other minerals. It is in the form of veins usually in plutonic or metamorphic rocks. Alluvial tin, washed from these rocks by denudation, is known as "stream tin," and possesses a high degree of purity. The British deposits of "stream tin" are nearly exhausted. The world's chief sources of tin are Cornwall, in England, and the Malay Peninsula. Less valuable deposits occur in Spain, Bohemia, Sweden, Australia, Africa, and Bolivia. The North American continent, so rich in other minerals, seems to have been very sparingly dowered with deposits of tin.

Alluvial Tin. As with gold, the first tin-workers confined their attention to alluvial deposits, which have been formed by the disintegration of portions of the stanniferous granite masses—the disintegrated portions being carried away after denudation and deposited in the lower valleys and river beds. The alluvial deposits in the Malay Peninsula are worked chiefly by the open-cast method, although in some cases hydraulic mining [see page 2959] is practised, and in exceptional instances shaft work is undertaken. They show up to 60 lb. of "black tin" or tinstone—which contains from 65 per cent. to 75 per cent. metallic tin—per cubic yard of gravel. The tin *wash*, as it is termed, is found from 2 ft. to 30 ft. under beds of clay and sand, and varies in thickness from a few inches up to 15 ft. or 16 ft. The "wash" consists of gravel worn smooth in its descent from the parent masses, and carries tin ore up to 30 per cent. of its weight. The Malay tin-miners are Chinese, and their tools and methods are primitive. The wash, as the name implies, carries much water, and after the overburden has been removed, the men work in swamps, which are drained in primitive fashion by Chinese wooden chain pumps and water-wheels.

The wash may be left in heaps to dry in the sun, in which case the clay becomes hard and may be removed, leaving gravel only. The method of concentrating the gravel ore is by putting it into a trough some 30 ft. long, with an inclined bottom; water is allowed to run over it, and the mass is agitated by men wielding long hoes. The sand is washed away by the running water, and the concentrate mineral—which is two-thirds tin—is sent to the cupola furnace to be smelted. The furnace used is small—about 5 ft. high—and is made of clay strengthened with stakes and girt with iron rings. Charcoal and tin ore are put into the centre of the furnace, which has an aperture in the rear for the supply of a blast, produced by hand bellows, and for raking. The smelted metal runs from a hole in the bottom into a depression made in the ground and is ladled into moulds in the sand, which give it the form in which it reaches the market.

The alluvial deposits of New South Wales are found under sand dunes [see page 1499] from 200 ft. to 300 ft. wide, and from 10 ft. to 20 ft. high, which have been formed parallel to the sea coast and run several miles inland.

These dunes are made up of a thick top layer of white beach sand, from 10 ft. to 15 ft. thick, under which are 2 ft. or 3 ft. of black sand, and finally about 1 ft. of gold and tin bearing sand on the top of red-brown sandstone rocks. The washing of this sand enables the recovery of the metallic tin, which is frequently associated with heavy proportions of gold and of good quantities of platinum, iridium, and other rare metals.

Tin Ore. *Cassiterite* (SnO_2), the oxide of tin, the form in which tin ore most frequently occurs, has a hardness between 6 and 7 according to Mohs' scale, a specific gravity of 6·8 to 7, and a chemical composition of 78·6 per cent. of tin and 21·4 per cent. of oxygen. These constituents vary in their proportions according as iron, manganese, copper, and other minerals enter into the composition of the vein. In appearance tin ore is dark red-brown or slate coloured.

Success in tin-mining depends more than in the case of most other base metals upon the skill which guides the mechanical preparation of the ore after mining. The ore is picked and sorted by hand, the non-stanniferous pieces being discarded and the true ore being put to one side. The latter is then passed through the stamp batteries. The stamp generally used in Cornwall weighs about 7 cwt., and makes about 60 drops of 10 in. per minute, crushing about 1 ton of ore every 24 hours. Greater efficiency could be attained by the use of more modern stamps, which would multiply output three or four times. The ore under the stamp is pulverised to a fineness that will pass through screens with about 144 holes to each square inch. The result is so much sand, and the problem now is to separate that part

of the sand which is really black tin from the worthless residue. To effect this separation, the greater weight of the black tin—which is rather more than double that of the sand—is made to assist. The crushed ore, carried by water, flows into tanks, known as *buddles*, which vary in form, but are similar in principle to those illustrated on page 5142. The heavy metallic particles sink to the bottom near the point where the mixture enters the tanks. The bottom of many of these buddles takes the form of an inclined plane, with ridges right across its face, and on these ridges the heavy stanniferous sand settles. Again, the bottom may be made to move either by an agitating or by a rotary motion, and the results of these modifications are better than those attained by the original type.

The recovered black tin still contains many impurities. It is now passed through *tossing tubs*, or *chimming tubs*, which work on the same principle as the buddles, and the further purified tin sand is known as *whits*. This is now calcined in order to decompose the arsenical pyrites. Again the *buddles* and *tossing tubs* are called into service as often as may be required to remove the impurities, and the result is a cleaned and concentrated tin sand which is the marketable commodity known as *black tin*, containing about 66 per cent. of metallic tin.

Smelting Tin. The furnace used for smelting is of the reverberatory type [see page 4126], with a bed about 18 ft. by 9 ft., and has a fireplace and a stack at opposite ends. The tapping hole is at the back, and is kept closed during the smelting. An ore charge weighs from 20 cwt. to 25 cwt., and after being incorporated with about one-fifth of its weight of anthracite powder it is spread evenly over the furnace bottom. If necessary, fluor-spar or lime may be added as a flux. The door is closed and "luted" up—that is, plastered up with clay—and the heat raised for five or six hours, after which the door is opened, the heated mass is "rabbled," or stirred up, and some powdered anthracite is spread over the surface. After being heated again for about an hour, and a further stirring, the furnace is tapped. The slag left is chiefly ferrous silicate, but contains some tin, and it is usually heated afterwards to remove this.

Refining Tin. The processes we have described carry us to the point of refining. The refining proper is preceded by a preliminary liquation in a reverberatory furnace, which takes a charge of about 18 tons. The temperature is carefully watched, and as it rises to the point of melting, the purer tin is run off into a special pot or "kettle" heated by a separate fire. The impurities—iron, copper, sulphur, and other constituents—remain as *hard head*, a white, brittle mass which contains about 20 per cent. of metallic tin. The purer tin, which has run off, is retained in a molten state in its own kettle, and logs of green wood are plunged beneath its surface. Under the heat the wood gives off gas, which causes agitation of the molten metal, and the formation of a scum containing the impurities. The same result is sometimes attained by pouring the metal from a height of 17 ft. or 18 ft. into the kettle, this process also producing the scum and removing the impurities. The operations we have described give the commercial products known as *common tin*, or *refined tin* according to quality. For the latter, purer ores are used, and the refining is prolonged. *Block tin* is a lower quality than refined tin.

Alloys of Tin. Apart from its use as a coating on baser and cheaper metals, the chief industrial use of tin is in alloying with other metals. Although it is a soft metal, in combination with other soft metals it forms a hard alloy. Lead alloyed with tin has a higher malleability and ductility than pure tin, but a lower toughness. All soft solders have tin as a constituent [see Soldering]. In addition to soft solder, the tin-lead alloys include pewter and tinfoil [see also page 5987]. Pewter was formerly used extensively in the manufacture of domestic utensils, but the solubility of the lead made lead poisoning frequent if the proportion of lead were high. The maximum proportion of lead which should be used in tin-lead alloys for culinary utensils is from 10 per cent. to 15 per cent. The acids of fruit have no appreciable effect upon such an alloy, but if the lead be in excess of this it dissolves and enters into solution in the food.

Alloys of tin and lead are used in a molten state for tempering steel tools. The finer the tools the higher is the proportion of tin. Thus, for razors, penknives, and surgical instruments the proportion is about two parts of lead to one part of tin; while for small saws, the amount of tin is only one-twelfth that of the lead.

Tin-copper Alloys. The tin-copper alloys include bronze, gun-metal, and bell-metal. Ancient bronze was a dual alloy, containing only copper and tin, but the French bronzes of to-day are made of triple or quadruple alloys, usually the latter, consisting of copper, tin, lead, and zinc, and sometimes in addition with small proportions of arsenic, antimony, nickel, and sulphur. The colour of a tin-copper alloy varies from red to white, as the proportion of tin rises. From 90 per cent. copper to 70 per cent. copper, the colour ranges from red to orange yellow, pure yellow, light yellow, and white. Bronze increases in hardness as the proportion of copper rises to 35 per cent. of the alloy. From this proportion to an alloy with 73 per cent. of copper the brittleness is high, but as the copper exceeds the latter value, the tenacity increases. Gun-metal has 90 per cent. copper and 10 per cent. tin, this proportion being the mixture of maximum hardness.

Tin-antimony Alloys. Tin alloyed with antimony gives bearings metal and Britannia metal. Such alloys are harder and less malleable than pure tin, but are equally white. Increase in the proportion of antimony increases the brittleness. Tin-antimony alloys should be cast at as low a temperature as possible, so that the excess of antimony may not separate from the eutectic alloy. Ordinary Britannia metal usually contains not more than about 10 per cent. of antimony, the remainder being tin. Sometimes a small proportion of the tin is replaced by copper, and occasionally zinc or bismuth is also employed. A small proportion of bismuth increases the fusibility. The points of merit about Britannia metal are that alloys of tin and antimony yield good sharp castings, are tougher than tin, and take a better polish than tin-lead alloys. The manufacture of Britannia metal hollow-ware, such as teapots and coffee-pots, used to be a much larger Sheffield industry than it is. Nickel-silver has displaced it considerably. Most of the Britannia metal-ware now made in Sheffield is electro-plated. It can be distinguished from nickel-silver, because when struck sharply it sounds as a dull thud, whereas nickel-silver hollow-ware similarly struck gives a clear, sonorous ring.

Antifriction Metals. Bearings metal or antifriction metal is frequently an alloy of tin and antimony, containing about 20 per cent. of the latter. It is usually, however, not a dual alloy, but contains also copper, lead, or zinc [see also page 5988]. The formulas given for antifriction metals are very numerous, but that the science of eutectic

alloys is imperfectly understood is proved by the large trade done in proprietary antifriction metals, the composition of which is not acknowledged.

Alloys of tin and zinc are harder than tin, but not so hard as zinc. Their use is limited. They are made into imitation silver leaf, and also cast into ornaments. The metals may be alloyed in all proportions.

Tin amalgam—that is, an alloy of tin and mercury—has a more restricted use than it had in the days when it was the agent adopted for silvering mirrors. Dentists use tin amalgam for filling teeth, one part of finely divided tin being triturated with four parts of mercury, and the excess of mercury being squeezed out in a chamois leather bag. The amalgam is pressed into the tooth and hardens in a few days.

Then we have alloys of tin, bismuth, and lead, used for type metal and printing blocks.

Tin-plates. Tin-plates are sheets of iron or steel, coated with tin. Sheets of Siemens steel are chiefly used for tin-plates, but charcoal-iron, which was, before the era of steel, the usual base, is still employed. Common qualities of tin-plate used to be made of puddled iron, and were known as *coke* plates, while *charcoal* plates were made from charcoal-iron. Bars of steel are made red hot, passed through chilled rolls, thereby being drawn out to about double length, folded in the middle, and again heated. Another rolling, another doubling, then another heating, rolling, and doubling takes place, until perhaps the final sheet contains as many as 32 plies. The sheets are trimmed to proper size, and the plies pulled apart, each ply then being a rough "black plate," so termed from its adhering coat of rough black oxide. This oxide must be removed before the plate can be tinned, and the operation, which is called *pickling*, is done with a warm solution of sulphuric acid in water for about fifteen or twenty minutes, followed by washing and rubbing with sand. *Annealing*, or maintaining at a high temperature for some time, then takes place. The annealing ovens are wrought-iron boxes of a size to hold the plates, and have removable upper parts, with joints that can be made tight against the ingress of air by being covered with sand. The annealing boxes are placed in a large furnace and kept at red heat for about ten hours, after which they are withdrawn, and the sheets are allowed to cool. After this, the sheets are rolled to give them smoothness, for a tin-plate can have a good surface only if the black sheet has had a smooth surface. The rolling may have made the sheets hard again, so a second annealing in cast-iron pots, and at a lower temperature, is given. Again the sheets are pickled, but in acid solution weaker than formerly, are rubbed with sand, and put into water to await the moment of entry into the tinning baths.

Plant for Tin-plates. The baths or pots used in the actual tinning process are usually five in number. The first is the grease-pot, which holds melted grease, such as tallow or palm oil, and the sheets are immersed in this until all water has evaporated from their surface, and they carry a uniform layer of grease. The second pot contains molten tin covered with a layer of grease, and the sheet is transferred from the grease and put into this, where it receives a coat of tin. The third pot is the washing-pot, also containing tin, and the sheet, with an imperfect coating taken on in the tin-pot, passes into the first compartment of the washing-pot, and acquires a uniform coating. The plate is removed and treated by a workman with a wire brush, who then puts the plate into the second compartment of the same pot, which is the final tin bath, and contains the best tin. The next pot is a grease-pot, in which the plate passes between carefully-adjusted rollers that remove excess of metal and give a better surface. The grease which adheres as it leaves this last pot is removed by rubbing with bran or sawdust, and a final surface is given by rubbing with a piece of the fleece of a sheep. The finished tin-plates are then examined for defects, and finally boxed for the market.

Varieties of Tin-plates. All the plates do not issue perfect. Defective plates are known as *wasters*, and if very bad, as *waste-waste*. In common tin-plates, *primes*—that is, sheets passed as perfect—usually amount to from 80 per cent. to 90 per cent. of the whole: but in charcoal plates the standard of quality allowed to pass inspection is much higher, and primes may be only 40 per cent. to 80 per cent. Wasters are sold as such, and there is always a market for them.

The commercial designations of tin-plate are very confusing, and the sheets are packed in boxes which are consistent neither in the number of sheets that they contain nor in weight. The table that follows gives the particulars of the various varieties and sizes. It is, indeed, time that some simpler method of packing and indicating tin-plates should be adopted. Cumbrous and awkward systems of reckoning also prevail in the manufacturing processes, but into these we cannot enter.

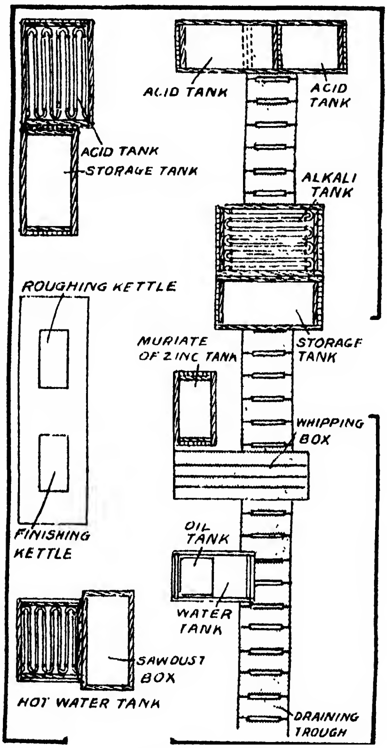
THE TIN-PLATES OF COMMERCE

Description	Mark	Dimensions of Sheets	Number of Sheets in a Box	Weight of Each Box
		Inches	Sheets	Lbs.
Common No. 1... ...	IC	14 × 10	225	108
Cross No. 1	IX	14 × 10	225	136
Two crosses No. 1 ...	IXX	14 × 10	225	157
Three crosses No. 1 ...	IXXX	14 × 10	225	178
Four crosses No. 1 ...	IXXXX	14 × 10	225	199
Common No. 1... ...	IC	14 × 20	112	108
Cross No. 1	IX	14 × 20	112	136
Two crosses No. 1 ...	IXX	14 × 20	112	157
Three crosses No. 1 ...	IXXX	14 × 20	112	178
Four crosses No. 1 ...	IXXXX	14 × 20	112	199
Common No. 1.. ...	IC	28 × 20	56	108
Cross No. 1	IX	28 × 20	56	136
Two crosses No. 1 ...	IXX	28 × 20	56	157
Three crosses No. 1 ...	IXXX	28 × 20	56	178
Four crosses No. 1 ...	IXXXX	28 × 20	56	199
Common No. 1.. ...	IC	12 × 12	225	108
Cross No. 1	IX	12 × 12	225	136
Two crosses No. 1 ...	IXX	12 × 12	225	157
Three crosses No. 1 ...	IXXX	12 × 12	225	178
Four crosses No. 1 ...	IXXXX	12 × 12	225	199
Common doubles ...	DC	17 × 12½	100	94
Cross doubles	DX	17 × 12½	100	122
Two-cross doubles ...	DXX	17 × 12½	100	143
Three-cross doubles ...	DXXX	17 × 12½	100	164
Four-cross doubles ...	DXXXX	17 × 12½	100	185
Common doubles ...	DC	17 × 25	50	94
Cross doubles	DX	17 × 25	50	122
Two-cross doubles ...	DXX	17 × 25	50	143
Three-cross doubles ...	DXXX	17 × 25	50	164
Four-cross doubles ...	DXXXX	17 × 25	50	185
Common doubles ...	DC	34 × 25	25	94
Cross doubles	DX	34 × 25	25	122
Two-cross doubles ...	DXX	34 × 25	25	143
Three-cross doubles ...	DXXX	34 × 25	25	164
Four-cross doubles ...	DXXXX	34 × 25	25	185
Small common doubles	SDC	15 × 11	200	167
Small cross doubles ...	SDX	15 × 11	200	188
Small two-cross doubles	SDXX	15 × 11	200	209
Small three-cross doubles	SDXXX	15 × 11	200	230
Small four-cross doubles	SDXXXX	15 × 11	200	251
Small common doubles	SDC	15 × 22	100	167
Small cross doubles ...	SDX	15 × 22	100	188
Small two-cross doubles	SDXX	15 × 22	100	209
Small three-cross doubles	SDXXX	15 × 22	100	230
Small four-cross doubles	SDXXXX	15 × 22	100	251

Terne Plates. Terne-plates are made in the same way as tin-plates, and differ from them only in that the coating given to the black plate is an alloy

of tin and lead. The proportions of the mixture vary, with different manufacturers, but a frequent and a satisfactory mixture contains 75 per cent. of lead and 25 per cent. of tin. Such plates are used extensively for roofing purposes, particularly in the United States, in Russia, and in mid-eastern Europe.

Uses of Tin-plates. Steam power and machinery have revolutionised the working of manufactured tin-plates. "Pieced" work, so-called—that is, articles made by the tinsmith, who cuts out and puts together pieces of the plate to make tin hollow-ware—has been superseded by the product of stamping machinery. The largest consumers of tin-plates in the world are the petroleum oil com-



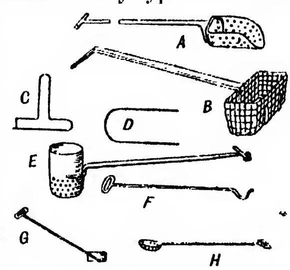
1. TINNING PLANT

panies of America and Southern Russia, who manufacture square tins in which to export much of their refined oils. The packing industries in Chicago and elsewhere are also large consumers, as well as the fruit and fish canners.

But besides the tinning of black plates, which is a localised industry, and in this country confined to South Wales, the process of tinning finds a wide scope in coating all classes of manufactured iron, steel, and metal articles, from pins to saucepans, from harness buckles to meat tins. For such work, a detailed description of the plant and processes may serve some good purpose in this article, because, while there is small likelihood that any student of these pages will desire to set up tin-plate works, it is more than probable that many may desire to install tinning plants as finishing departments of metal-working businesses.

Tinning. The operation of tinning resembles in many respects that of galvanising by the hot process. Articles are galvanised to protect them from rust. The more expensive process of tinning has the same object, but the zinc coating of the former process is not suitable for articles for culinary purposes, and in the sphere of cooking utensils and for food containers tinning finds its greatest field. Tinning also remains brighter than galvanising, although those not thoroughly familiar with the distinctive appearance of galvanising and tinning may often mistake a badly tinned article for a well galvanised article. Tinning was in vogue for coating articles of malleable iron, and of wrought iron and steel long before it was used for common cast iron. The process upon the latter material is a little more difficult, and it will demand special treatment.

Tinning Plant. A description of a tinning plant will be more lucid if we take a typical case, but it cannot be claimed for any typical case that its details are suitable for all cases. The requirements of the work must modify the details in installing a plant for a particular purpose. A good general arrangement for a tinning shop is shown in 1, and the purpose of the various fixtures will be explained as we describe the process. The small hand tools necessary are modified by the nature of the work done, but the tools shown in 2, and also used for galvanising, serve most purposes in the tinning shop.



2. HAND TOOLS FOR GALVANISING AND TINNING
A. Dross scoop *B.* Wire dipping-basket *C* to *F.* Wires for small work *E.* Sheet-iron basket *G* and *H.* Skimming tools

Preparing the Work. The smoothness of the coating of tin depends quite as much upon the metal surface as upon the even deposition of the tin envelope. Common articles are cleaned from rust, sand, and adhering dirt, by immersion in acid—sulphuric acid, muriatic—otherwise called hydrochloric acid—or hydrofluoric acid. Where a better coating is desired, the articles are further prepared by rolling them in special barrels with gravel and water. These barrels, made of a convenient form and size for the work, are caused to rotate upon a horizontal axis, and the agitation and friction makes the articles within smooth to a degree proportionate to the time during which they are subjected to this treatment. When extra fine results are desired, the articles may receive a second rolling in coarse dry sand, and even a third rolling in scraps of leather, but common work seldom warrants the expense of this extended treatment.

Wrought iron and steel can have rust and scale removed in a pickle made of sulphuric acid diluted with water to thirty times its volume, or with muriatic acid diluted to fifteen times its volume. Hydrofluoric acid is sometimes used, and is much quicker in its action, and is less likely to injure the castings. The strength is from 1 in 20 of water to 1 in 30. The pickle should be kept warm at, say, 150° F. Stirring is necessary during the process if the articles are of such a form that the surfaces of different articles are liable to rust in the bath in contact with each other, thereby preventing the acid from getting to its work. Sheets of iron or steel are placed in wooden racks arranged to keep them apart. Every article should be examined

individually as it comes from the bath, and if not satisfactory, should be subjected to further treatment, or should have any scales removed with a pointed instrument, such as an old file. Small articles are then "rolled" in barrels, as already described. This process does not increase the adhesion of the tin coating; it merely gives a smoother surface. Over-pickling, which is apt to follow the use of sulphuric or muriatic acid, makes the work pitted, and care must be taken to avoid it.

If the articles be sandy, every particle of sand must be removed, or bad work will result. This may be done in the manner described later for preparing work to be galvanised. Washing with the aid of wire brush rubbing may be necessary to remove the sand perfectly.

Malleable castings should always be rolled with dry, sharp sand or shot, to secure a good surface. If the articles have paint or grease on their surfaces they should be immersed in a hot, strong solution of caustic soda, and then washed in clean water, finally going to the pickling tank to have the rust and scale removed.

After being cleaned by one or more of these processes, the articles are put into a tank with clean water—not into running water, which would cause oxidation—until they are wanted for the tinning kettle.

Dipping the Articles. Small work is usually strung on wires for immersion. Make the wires long enough so that there may be plenty of room to put the articles well into the tin. Take a wire laden with articles, immerse the latter for a few minutes in a tank containing a solution of muriatic acid (1 to 5) to remove any remaining traces of rust, then into muriate of zinc solution (zinc chloride) made by dissolving zinc in muriatic acid to saturation point, and finally put into the kettle of molten tin.

Common work is often done in a plant with only one tinning kettle. The diagram [1] provides for two kettles, which are almost essential. With one kettle the slag or dross which accumulates on the surface is apt to adhere to the finished articles.

Several wires filled with work are put into the kettle and allowed to remain there until the articles are as hot as the tin, which should be about 500° F. When this point is reached the work is withdrawn, care being necessary in the manner of withdrawal. With a ladle held in the right hand, clear the surface of the molten tin free from slag, so that no slag or flux may be carried away by the articles as they are withdrawn. Then withdraw a laden wire and plunge it immediately into the second kettle, which should have a temperature of about 400° F., or 450° F. for very small articles. Care should be taken that none of the surface slag or flux is taken over by the work into the second kettle. The second kettle should have a layer of tallow on the top, to the depth of ½ in. or 1 in. When the temperature of the articles in the kettle has fallen to that of the second kettle they are withdrawn, swung around sharply so as to throw off any surplus metal, and then thrown into a tank of kerosine oil. This tank has a water jacket, preferably with circulating water, to prevent the oil overheating. In this tank the tin coating sets, and when the work is withdrawn from it, which may be at any convenient time after the tin has set, it is thrown into clean sawdust, which takes up the oil. The operation of tinning is now complete, and if the proper method has been followed, and care exercised, the articles have a smooth coating, uniform in depth and colour.

Preparing Gray Cast Iron for Tinning. To get a good coating on common gray cast iron, several precautions in addition to those used for ordinary wrought iron and steel, and for malleable cast iron, are necessary. If grease or paint be present, or if there be traces of resin from resin cores used in the moulding, the articles should be washed in a strong hot aqueous solution of caustic soda, as already described for removing grease in tinning wrought iron. Castings have always some adhering sand; this should be removed with hydrofluoric acid and water, as already described. Sulphuric acid or muriatic is often used, but hydrofluoric acid is preferable, as it dissolves the sand—not dislodging it only—and does not attack the iron as the other acids do.

Of the several other processes employed to make common gray castings suitable for a deposit of tin, one successful process may be described. A special tumbling barrel, containing a mixture of muriatic acid, sal ammoniac, and water, is used. The barrel should be much stronger than an ordinary tumbling barrel. A body ⅜ in. thick, with cast-iron heads 1½ in. thick, are good sizes. The manhole cover will serve if 1 in. thick, and well supported with ribs. This strength is necessary to withstand the action of the gases generated by the chemicals used, and valves should be provided to permit the escape of these gases. Place the cleaned castings in this barrel, and let one-fourth of the inside capacity be occupied by "stars"—small castings of the shape indicated by the name and used in ordinary tumbling—and shot; then add water until the barrel is three-quarters full, and finally put in 15 lb. of muriatic acid, and 2 lb. of sal ammoniac. Close the manhole and set the barrel in revolution. Soft iron requires about 2½ hours of such rolling, and hard castings may require double this time.

Then the work is withdrawn from this barrel and placed in the storing tank (containing clean water) until it is to be put into the kettle to receive its bath. When that time comes the castings, either strung on a wire or in a wire basket, are immersed in a boiling solution of caustic soda or potash for about two minutes; this is followed by rinsing in water, then by a bath in a weak solution of muriatic acid (1 in 40), then by immersion in muriate of zinc —prepared as already described—to every gallon of which 5 lb. of sal ammoniac has been added, and finally, into the first tinning kettle at 500° F. This kettle should have a special flux on the surface prepared by boiling muriate of zinc on top of the tin and adding thereto some sal ammoniac. The consistency of this flux is an essential to good work. If it tends to become thick or hard, add more of both ingredients, and remove any hard part with a skimmer. Then the second kettle is called into operation in due course, and as already described, and the subsequent oil bath and sawdust.

Recovering Waste Tin. Many thousands of pounds sterling are wasted annually in the tin which adheres to tin-plate scrap, and many solutions of the problem of how to recover this tin have been sought. Nearly all successful processes are secret.

Any process of recovery which has depended upon an acid solvent has proved far too costly. The solvent invariably attacked the iron below the tin, became soon exhausted, and had to be frequently renewed. Success is possible only by an electrolytic process, similar to that employed in the manufacture of electrolytic copper. One such process may be described. The electrolytic bath is said to be a solution of caustic soda, or of sodium nitrate, and the scrap tin-plate, of course, forms the anode.

The tin-plate scrap, freed from grease if necessary, and compressed so as to take up as little room as possible, is suspended in wire baskets in a wooden tank. Between the various baskets copper cathode plates are suspended. Both the baskets and the cathode plates are suspended so as to be clear of the bottom of the tank, where sludge accumulates. The solution is made of 30 lb. of caustic soda in 100 quarts of water, and in use is maintained at about 150° F. by an exhaust steam coil. The solution is made to cover both baskets and the cathode plates. The electric current causes the tin to deposit on the cathode plates as a spongy mass, which is easily detachable by hand. This mass must not be recovered in the presence of air, or it would oxidise away. It is covered with powdered charcoal and coke breeze, and is melted in a closely-covered crucible.

ZINC

Zinc was one of the last of the common metals to come into extended industrial use. There is evidence that it was known to the ancients, because zinc bracelets have been found in the ruins of Eastern cities which were destroyed several centuries before the opening of our era, but the knowledge was evidently lost, because during the long Middle Ages zinc was unknown to Europe as a metal. True, brass used to be manufactured by heating copper in a mixture of calamine (the ore of zinc) and charcoal, but the metal zinc was not known to be procurable from this ore. During the third decade in the eighteenth century Henckel discovered that zinc could be obtained from calamine. But it was about a century later before what may be termed the zinc industry was established. Thus, zinc may be said to be about one hundred years old as a commercial product, and the process of galvanising, or coating iron sheets with molten zinc, to impart powers of resistance to corrosion, was first applied only seventy years ago.

The world's chief sources of zinc ore are Germany, Italy, Spain, France, Sweden, Austria, Algeria, Great Britain, New South Wales, Greece, and Belgium, this being the order of importance. The chief producers of zinc are Germany, Belgium, France, and Great Britain, in the order named. Thus, the smelting and refining of zinc ores does not belong essentially to the districts where the ores are found. Zinc ores carry high percentages of zinc, so that transport in their unreduced state is relatively inexpensive.

Zinc Ores. There are two main zinc ores—*calamine*, or carbonate of zinc ($ZnCO_3$), and *zinc blende*, or sulphide of zinc (ZnS), which the miners term "black jack," on account of its deep black colour. Minor sources are the oxide of zinc, which usually occurs in combination with oxide of manganese and zinc silicate.

Characteristics of Zinc. Zinc is a bright bluish white metal, with the atomic weight 65·4, a specific gravity of about 7·125, which rises if it be cooled rapidly, and a melting point of 415° C. In Mohs' scale of hardness its place is 2·5. Its boiling point is 920° C., but it burns in the atmosphere at a temperature of 500° C. The texture of zinc is laminar, sometimes granular. Its fracture is granular or crystalline according to the temperature to which it has been raised in casting, and is easily recognisable. When heated over 100° C. the metal becomes ductile and may be rolled into rods or sheets, or drawn into wire. After cooling subsequent to this treatment, it remains ductile. The tensile strength of zinc is between 7,000 lb. and 8,000 lb. per square inch of section; its thermal conductivity is 28·1 (silver = 100), and its electrical conductivity is 16·92 (mercury at 0° C. = 1).

The ores are formed in two distinct forms—in mineral veins and in irregular deposits. Of the former class zinc blende is the most abundant, and within the last two decades it has taken place above calamine, which was the first form of zinc ore to be treated.

Preparing Zinc Ores. Since the inception of the zinc smelting industry, the plants and processes employed have undergone modification, and we shall consider only those practised to-day in modern works. There are two main processes, termed respectively the Belgian and the Silesian. They differ in the retorts and furnaces used, and in the methods of handling the ore. Zinc ores, having been raised to the surface, are concentrated so that the cost of furnace treatment may be reduced. Concentrating merely means rejecting the valueless or objectionable portions of the ore mass, leaving the selected rich pieces to be treated. Three processes of concentrating are in practice, and specific ores may be subjected to one, to two, or to all three of these processes, which are hand separation, gravity separation, and magnetic separation. The processes employed in individual cases depend upon the class of ore under treatment.

The ore as brought from the shaft is usually broken either mechanically by jaw crushers or by hand. The latter practice is the better, although the more costly. It is usually practised when low wages rule in the district. Hence it is common in Central Europe, but infrequent in America. Mechanical breaking causes too heavy a loss by making "fines," or dross, and it is valuable zinc-carrying rock that is most easily made into fines. Hand-breaking with hammers is thus the better practice.

Having been broken, the ore is screened to remove the fines. The remainder is then sorted by hand. The best method is by a circular revolving table, or by a long belt conveyer. In either case the work moves in front of the operator at suitable speed, and he or she (for in Continental Europe the sorters are often women) removes the pieces according to instructions, putting the waste aside and retaining the blende or calamite as the case may be.

The process of gravity separation requires, first, that the ore should be crushed to such a fineness that the minerals are well separated. The crushed ore is carefully screened, which grades it into various sizes, and each size is washed and treated by itself in tanks or buddles, such as are used in other metallurgical processes, and which are described in Tin Recovery.

The magnetic separation in zinc ore concentration is practised in New South Wales and in America. It is somewhat costly, involving the use of expensive plants, but it has been found to be remunerative. Zinc and zinc compounds are non-magnetic, or, at most, only feebly magnetic. But if the associated minerals in the zinc ores are magnetic, they can easily be separated by magnetism. For instance, in Bohemia iron in the form of siderite is separated from zinc by heating the mass, then grinding it and screening it, and finally treating it in magnetic separators. In Pennsylvania also the zinc ores which carry franklinite, willemite, calcite, zinkite, and tephroite, are separated by a direct magnetic process without previous roasting.

Calcining Zinc Ores. When the ore has been concentrated in the manner described, it must be calcined, to remove the carbon dioxide and water, and also to make it more porous. Roasting decomposes carbonate of zinc into zinc oxide and carbon

dioxide, and nearly all of the latter is driven off. The roasted mass weighs only about 65 per cent. of its original weight.

The process of roasting may be carried out in the open, the ore being piled in heaps, or it may be done in reverberatory or shaft furnaces. The first method is the most costly and wasteful, and is not suitable for calamite, although it was formerly employed for "blende" ores. Some sulphide ores (such as nickel ores) are roasted in the open, as their sulphur contents supply a great proportion of the heat necessary for their calcination. Thus for zinc a furnace of some sort is almost invariably employed. A common shaft furnace of the limekiln type may serve, but it has the objection that the calcined ores are mixed with the fuel ashes. Such furnaces run to 20 ft. high, and treat up to 30 tons each 24 hours, the fuel consumption being from 3 per cent. to 6 per cent. of the ore before treatment. The shaft furnaces are sometimes grate-fired: these give a cleaner result, but are more expensive in fuel charges, these running from 6 per cent. to 9 per cent. of the raw ore. Their capacity also is only half that of the ordinary shaft furnaces.

Several varieties of the reverberatory furnace are employed, and these furnaces are the only suitable means of treating "fines." They are more expensive than shaft furnaces in both labour and fuel. Sometimes they are heated by the waste gases from reduction furnaces. In Kansas and Indiana natural gas supplies the fuel.

Calcining Zinc Blende. *Blende*, the sulphide ore of zinc, must be calcined to reduce the sulphide to an oxide, and the contained carbonates, if any, must also be converted into oxides. In practice, it is found impossible to remove the sulphur entirely, and up to about 2 per cent. may remain. The ore must be finely crushed, and may not be coarser than can pass a mesh of $\frac{1}{12}$ in. Calcination of zinc blende reduces its weight by 12 per cent. to 20 per cent. The operation is performed in shaft, reverberatory, or muffle furnaces. Preliminary roasting is frequently conducted in shaft furnaces, and the sulphur, which may have been up to 30 per cent. to 35 per cent. of the raw ore, is reduced to 7 per cent. or 8 per cent. The sulphur dioxide given off may be used for the manufacture of sulphuric acid [see page 4627].

The final roasting when shaft furnaces are used for the preliminary roasting—or the only roasting if the shaft furnace has not been used—takes place in either a reverberatory or a muffle furnace. The former is adopted when the gases given off are not to be used, and the latter when they are to be used for sulphuric acid manufacture. Muffle furnaces yield gases rich in sulphur dioxide, and calcine the ore thoroughly. The gases of reverberatory furnaces, on the other hand, give gases very low in sulphur dioxide, which cannot be profitably utilised. Before the gas can be allowed to pass into the atmosphere, however, it must be diluted or otherwise treated so as to render it innocuous.

Zinc Distillation. The next process in the treatment of zinc ore after it has been concentrated and converted into oxide is the recovery of the metal by distillation. Zinc oxide when heated to a high temperature is reducible by carbon or carbon monoxide. Practice employs a heat of 1300° C., although the precise reduction heat is below this. The metal is reduced in retorts or muffles to the form of vapour, which is liquefied by cooling to about 500° C., and is collected in clay vessels called *receivers* or *adapters*.

The Belgian retorts have a round section, the Westphalian are of oval shape with a flat base, and the Silesian are ⌂-shaped. They are usually made of fireclay and burnt clay, and it is essential that they should be of as refractory a nature as possible. The receivers or adapters in which the zinc vapour condenses are short tubes of clay which are luted to the end of the retorts. The furnaces in which the retorts are heated are shaft furnaces, and are fired externally. The retorts are ranged in tiers, and slope forward in the furnaces. The zinc oxide is charged into the retorts with from 40 per cent. to 60 per cent. of its weight of coal or coke. Sometimes the charge is pressed into blocks with tar. The actual process of distillation requires care. The furnace is fired for some days before the retorts are charged, and at first the charges which are introduced into the retorts after removing the adapters are light, but are gradually increased. A retort charge is usually about 63lb. of ore, and is reduced in twelve to twenty-four hours. The condensed zinc is raked into ladles from the adapters into iron moulds, and forms ingots weighing from 40 lb. to 44 lb. After a charge has been reduced the residue is raked from the retort, which is again charged with a fresh supply of material, and the process is repeated as before.

Refining Zinc. The zinc drawn from the adapters may be sufficiently pure for commercial purposes if the ores have been carefully selected, but it may, on the other hand, contain fair proportions of iron and lead, which can be removed by a simple process of refining. The crude zinc is melted gradually again, and kept in that state for some time. The iron rises to the surface, and may be removed as scum. The lead sinks to the bottom and the zinc may be drawn off, leaving the lead; or the underlayer of lead may be removed by an endless screw working in a cast-iron pipe. The higher the purity of the zinc the greater its value, and while pure zinc is almost impossible to obtain, care in selecting the ores and in the subsequent treatment will give something approaching chemical purity.

Zinc Alloys. The most important use of zinc is in the galvanising trade, and the processes of galvanising are discussed later. The next most important use is as a constituent of alloys. In alloying, many metals—including tin, nickel, aluminium, manganese, iron, and copper—exercise a stronger colour influence than zinc, while zinc has a stronger colour influence than lead, platinum, silver, and gold. This means that the metals which we describe as having a stronger colour influence impart their colours to those lower in the scale to an extent much higher than their proportion of the alloy. The most important binary alloys of zinc are with copper and with aluminium. Zinc-copper alloys form brass and yellow metal, and these constitute a science in themselves [see next article]. The two metals unite in all proportions, but for industrial use the proportion of copper is seldom less than 50 per cent. When zinc is in excess the alloy loses strength, and the higher the excess of zinc the weaker and harder is the alloy. Increase in the copper proportion of a zinc-copper alloy gives a deeper colour, at the same time increasing the malleability and softness. Alloys having up to 35 per cent. of zinc can be rolled and drawn only if cold; if the zinc proportion be from 35 per cent. to 40 per cent., the alloy can be worked either cold or hot. Brittleness, and therefore difficulty of working, increases as the zinc increases. The most ductile alloy contains from 15 per cent. to 20 per cent. of zinc, and sheet brass for fine work has this proportion. Brass for

cartridges has 28 per cent. of zinc. Cast brass usually contains more zinc, as it is the cheaper ingredient, from 30 per cent. to 40 per cent. being common.

Alloys of zinc and aluminium are important industrially, especially since the reign of the motor-car began. Castings containing from 25 per cent. to 33 per cent. of zinc are clean and sharp, besides being very strong and capable of being machined easily.

With lead, zinc has very little alloying power, as the two metals unite to a very small extent. Each of them can dissolve not more than 1·6 per cent. of its fellow. Bismuth and zinc are also unsuitable for alloying. It has been found that zinc can dissolve only 2·4 per cent. of bismuth, and bismuth can dissolve not more than 14·3 per cent. of zinc. Zinc amalgam—that is, an alloy of zinc and mercury—is used in the zinc anodes of galvanic batteries. In its preparation, a zinc plate is heated to about 500° F., and after being coated with a brush with a solution of chloride of zinc and ammonia, it is dipped into mercury. Anodes prepared thus give currents more constant and intense than do ordinary zinc plates.

Sheet Zinc. Zinc has been used as a roofing material for about a century. Nowadays, galvanised steel sheets have a much wider application than zinc sheets for roofing. But the life of a galvanised iron roof is seldom longer than fifteen years, even with periodical painting, while the life of a zinc roof is indefinite. Some zinc roofs are in good condition after forty years of service. The sheets of zinc used for roofing should not be soldered when they are to be subject to wide degrees of temperature, as the contraction and expansion of zinc is higher than those of other roofing metals. Nails used with zinc roofing should be of zinc, or, at least, should be galvanised. A zinc roof has the advantage of lightness, being only about one-fifth as heavy as a lead roof—zinc sheets being thinner than lead sheets—and one-tenth as heavy as tiles.

Other uses of zinc sheets include their suspension as plates in boilers to prevent corrosion of the boiler shells. The galvanic current which they induce causes the lime and organic matter to act upon the zinc instead of on the boiler, thereby protecting the latter. Thin zinc sheets, sometimes purchased as flat discs and sometimes turned off the zinc bar in spirals, are used in gold extraction by the cyanide process. Perforated sheet zinc—the perforations being round or ornamental in form—is used extensively for ventilators, and for domestic meat safes. As lining for packing-cases and coffins, as a material for hollow-ware, such as watering-cans, buckets, etc., sheet zinc has a limited but useful consumption. The printing trades use zinc extensively for process blocks.

Other Uses of Zinc. Zinc castings—except so far as zinc enters into brass as an alloy—have not an important industrial use, but many cheap ornaments are made of cast zinc, electroplated or otherwise finished.

Zinc oxide, or *zinc white*, as it is termed commercially, is prepared by burning zinc and leading the fumes into condensing chambers. It is used as a pigment, and also in medicine. *Zinc chloride* is used as a caustic in medicine, and also for weighting cotton goods, and in mercerising cotton. *Zinc sulphate* is used in dyeing, in calico printing, and in medicine.

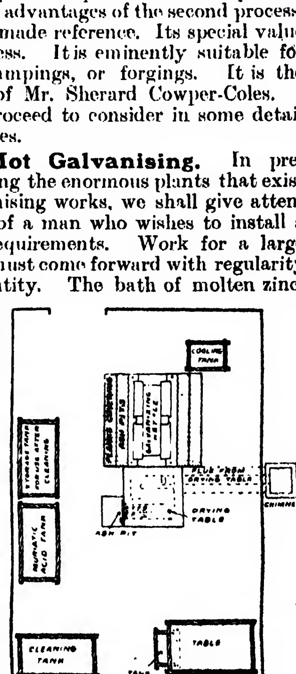
Among the cheaper metals, zinc excels in the property of resisting atmospheric action. For this reason iron and steel, and sometimes other metals, are given a thin coating of zinc, which presents a closed surface to the agents of corrosion and oxidation, and prevents these latter from penetrating to the surface beneath. The process of zinc coating is termed *galvanising*.

Processes of Galvanising. There are three different processes of galvanising—the hot process, the electrolytic process, and the dry or oxide process. The first named is the original process, and is practised by nearly every firm who do galvanising work. It has many advantages, although it has a few disadvantages; but the former have, up to the present, been held to warrant faithfulness to it. It is suitable for all classes of work—sheet, cast, and wrought iron and steel. The plant must be large enough to handle the articles to be galvanised, of course, but there is no class of work that cannot be undertaken by it. No other method is suitable for what is termed *galvanised hollow-ware*—that is, articles such as buckets, bins, water-pots, and other containers of sheet iron or steel that have to be galvanised. Such articles are made with seams which are not always watertight, but the molten zinc during the process of galvanising lodges in these seams, doing duty as a solder, and rendering the vessel free from leaks. The hot process also is capable of giving a *watered* or *spangled* effect which no competing process hitherto tried is able to produce. This surface is for some purposes better than the uniform gray surface attained by other processes. It may be noticed often, but not always, on galvanised corrugated iron and on galvanised buckets. The second process, that of electrolytic deposition, has as its recommendation that it uses much less zinc than the hot process, and may be less expensive; the coat is more uniform than that given by the hot process, and it may be utilised by firms who have not a special galvanising plant, but who have an electroplating plant.

The third, or dry process, is the most recently introduced and has not yet been widely adopted. Except that it requires a special and an expensive plant, it has all the advantages of the second process, to which we have made reference. Its special value lies in its cheapness. It is eminently suitable for small castings, stampings, or forgings. It is the patented process of Mr. Sherard Cowper-Coles.

We may now proceed to consider in some detail the several processes.

Plant for Hot Galvanising. In preference to describing the enormous plants that exist in the large galvanising works, we shall give attention to the needs of a man who wishes to install a plant for small requirements. Work for a large galvanising plant must come forward with regularity and in large quantity. The bath of molten zinc, usually containing several tons of metal, must be kept hot constantly whether work is going through it or not, because if the bath, or *kettle*, be allowed to cool—that is, to solidify—it cannot be melted again without breaking up the kettle—an enormous expense which every galvanising works manager is careful to avoid. But nothing so

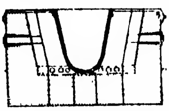


3. GALVANISING PLANT

disastrous follows the solidifying of a kettle containing two or three hundredweights of zinc, although it is better that even these should be kept in constant work.

A galvanising plant should be situated in a separate building, as the fumes from the acid used are destructive to tools and machinery. The building should be well ventilated, the water supply abundant, and the drainage perfect. In **3** we show a good arrangement for a galvanising plant, and the various parts of the plant should be as follow.

Galvanising Kettle and Tanks. The kettle is a long trough built in brickwork, having flues some way up the sides. It should be not less than 36 in. long, 20 in. deep, and 18 in. wide. This size would be of no use for large work, such as corrugated sheets, which, however, would not be handled by a small plant. The kettle should be made of best fire-box steel, not less than ½ in. thick. A good sectional view of an efficient kettle of small size is shown in **4**. The fire underneath must be of a size to keep the zinc in a molten condition.



4. GALVANISING KETTLE

The tanks for acid and cleaning liquid are merely rectangular boxes of a suitable size. If it be desired to economise, an oil barrel, sawn in halves, will make two suitable tanks. It is sometimes considered well to have the acid tanks lined with lead, but this is by no means necessary, and the expense may well be saved.

Sundry Tools. The hand tools used by galvanisers consists of tongs of a shape suitable for the work to be undertaken, of baskets of woven wire or perforated iron, and sundry wire tools, bent to different shapes. In **2** are shown some tools generally used, and the description attached explains their purposes sufficiently.

Firing the Kettle. Some precaution is necessary in firing a kettle for the first time. The fire should not be allowed to raise too great a heat before the zinc, or *spelter*, as ingot zinc is called, has begun to melt, or the shell of the kettle will suffer. The blocks of spelter should be made to lie right on the sides of the kettle, so that as the blocks next the kettle melt the other blocks will be forced into the same positions. The bath may be kept at a uniform temperature by the use of a pyrometer, and some device is usually adopted to prevent the stem of the pyrometer from contact with the molten zinc, although making the same record as if it were in direct contact. A device sometimes adopted is to have the pyrometer stem in a steel tube, closed at its lower end and filled with lead, in the middle of which the stem rests.

Removing Scale. Most work to be galvanised must have scale and rust removed before it is sufficiently clean to result in good work. This process is known as *pickling*. It is accomplished by immersing the work in a solution of 1 part of muriatic acid (otherwise known as hydrochloric acid or spirit of salt) in 20 parts of water. It may be necessary to assist the removal of the scale with a tool such as a wire brush or file. A weaker acid solution should be used for work with an unequal scale, otherwise *over-pickling* may take place, and this seriously prevents the adhesion of a good deposit of zinc. Sandy castings are cleaned by pouring over them a solution containing one part of sulphuric acid to six parts of water. They should be placed on a table or tray, and have the solution poured over them about every hour until the sand can be entirely removed by washing with water.

The Acid Bath. The work is immersed in muriatic acid before going into the zinc kettle. This acid serves as a flux, and also cleans the surfaces finally. If the work has some adhering rust, it should be kept in this bath long enough to remove the rust. The acid used is sometimes full strength, but a better bath is equal parts by volume of muriatic acid and water, with 1 lb. of sal ammoniac added to each gallon of liquid.

From the acid bath the work is taken to be dried, and many methods of drying are adopted. In a small plant, the drying table may be heated from the fire that supplies the kettle, but in big plants separate fires are used for drying the work. The muriatic acid should be apparent on the dried work as a white adhering powder. After drying, the articles should be put into the zinc kettle before they become cold.

The Molten Bath. The molten zinc should be at a temperature suitable for the work being put through, and a pyrometer is the only means of getting exact results. Different classes of work require different degrees of fluidity, or, in other words, different degrees of heat. For large gray iron castings, the metal should be about 775° F., and for thin work, where the spangled effect is desired, this heat is right. For wrought-iron pipe, heavy malleable castings, and small castings used without a flux a good temperature is about 840° F. For nails and other small work, hung on wires or immersed in baskets, about 880° F. is the best heat. The surface of the molten bath at the place where the article is about to be dipped should have thrown on it a few handfuls of sal ammoniac, which, whenever it is melted, should be followed by a few drops of glycerine, to restrain it from spreading over the entire surface.

Dipping. The manner of dipping the articles depends upon their nature. Washers, for instance, are strung on wires, nails and small articles are put into wire baskets, and large articles are simply held with tongs. The immersion should be made as quickly as possible, without causing sputtering, and the article should be held beneath the surface of the molten zinc until it is as hot as the zinc itself. This time cannot be judged by rule, and the only teacher is practice. When the article, say, a thin casting, has been immersed some time, it should be rinsed around a little. Before removing it, clear a space on the surface where it will emerge, and dust that part of the surface with a little sal ammoniac in powder. With one pair of tongs raise the article out of the metal, and with another pair, not dipped into the actual bath, complete the withdrawal. Some goods, such as galvanised hollow-ware, require immersion for only a few seconds, and the surface need not be sprinkled with sal ammoniac before withdrawal. Indeed, slight differences in the minute details of the practice give better work with different articles, and all these details can be learned only by practice. Wire and netting are run through the bath by a reel arrangement, and some galvanisers of corrugated sheets adopt a revolving wheel device to throw up the sheets after coating. The particular practice must be adapted to the particular work to secure the greatest possible economy.

Cooling. The articles are sometimes allowed to cool in the air, are sometimes immersed in cold water at once, and, sometimes, again, the cooling water is heated, so that the cooling may not be too sudden. If the article has taken on any of the sal

ammoniac floating on the surface, a wet brush may be used to remove it.

Dross. Every galvanising kettle accumulates dross. This is caused by impurities and dirt which accompany articles into the bath and remain behind, and sometimes by having the metal at too high a temperature. The dross should be removed periodically, as it retards the work and causes fuel expense if it remain. It is removed with a dross scoop [2], and must be done smartly, and deposited quickly, before it has time to harden on the scoop. The good zinc is sometimes recovered from the dross by heating to a high temperature—over 1,000° F.—with lead. The mass, on settling, has the lead at bottom, with the dross next to it, and the good zinc at the top, whence it may be removed and utilised.

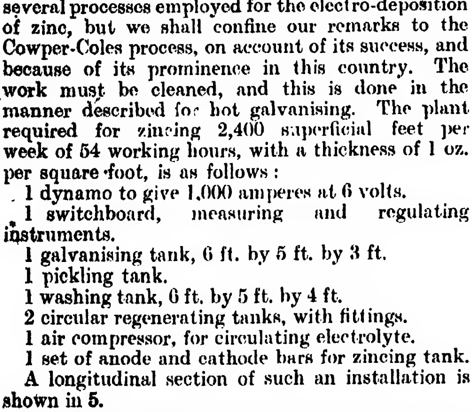
Electro-galvanising. The second process of galvanising, to which we shall devote some attention, is the electro-deposition of zinc. Where the highest degree of adhesion of the zinc to a piece of iron or steel is sought, it is attained best by the method of electro-deposition. Thus, for boiler tubes, and for the hulls of torpedo boats, electro-zincing or electro-galvanising is superior to the "kettle" method. Exhaustive tests have shown that electro-galvanising does not diminish the tensile strength of the material to which it is applied, as does hot galvanising. Also, the coating imparted can be gauged much better than with the more common process.

The Cowper-Coles Process. There are several processes employed for the electro-deposition of zinc, but we shall confine our remarks to the Cowper-Coles process, on account of its success, and because of its prominence in this country. The work must be cleaned, and this is done in the manner described for hot galvanising. The plant required for zincing 2,400 superficial feet per week of 54 working hours, with a thickness of 1 oz. per square foot, is as follows:

1 dynamo to give 1,000 amperes at 6 volts.
1 switchboard, measuring and regulating instruments.
1 galvanising tank, 6 ft. by 5 ft. by 3 ft.
1 pickling tank.
1 washing tank, 6 ft. by 5 ft. by 4 ft.
2 circular regenerating tanks, with fittings.
1 air compressor, for circulating electrolyte.
1 set of anode and cathode bars for zincing tank.

A longitudinal section of such an installation is shown in 5.

The Zinc Bath. Various zinc baths are used by different workers. That recommended by the inventor of the process consists of zinc sulphate 350 oz., sulphuric acid 1 oz., and water 10 gal. To obtain good



5. ELECTRO-GALVANISING PLANT

bright deposits of zinc, the solution should be kept as free as possible from impurities, and if the electrolyte be too acid, a rough dark zinc coating will be given.

The work to be zinced is secured to dogs fixed to cross bars, which rest on copper strips attached to girders carrying the anodes, which are of lead instead of zinc. It was found that zinc anodes failed to keep the solution up to normal strength, disintegrating and causing a rough uneven deposit, and as the solution is regenerated by circulation between the electrolytic tank and the regenerating tank, lead anodes were tried with success.

Regenerating the Electrolyte. The accepted and economical method of regenerating the electrolyte is by adding to the regenerating tank zinc dust or tultz, preferably mixed with sand or coke, so as to form a filter bed and to prevent the dust from entering the depositing tank, where it would increase the electrical resistance. By the system of circulation caused by the apparatus, the electrolyte flows into the bottom of the depositing tank by gravity, the impoverished and therefore lighter liquid being drawn off over a sill at the end of the vat. When the articles are first placed in the bath, it is found well to use as high a current density as possible, and after a few minutes to reduce it to about 15 amperes per square foot.

Such, in brief, are the chief features of the process of electro-galvanising. On the score of economy, it has much to commend it for certain classes of work. When not in constant use, a large hot plant demands a very great expense to keep the mass of zinc in a molten condition, a necessity which does not exist with the electrolytic process, and this consideration is sometimes of paramount importance.

Sherardising. A process known as *sherardising* has been recently introduced, and it is properly a process of galvanising by quite a new method. An account of galvanising would be neither complete nor up-to-date if it did not take notice of it. By the process of sherardising, the articles to be rendered non-rusting are cleaned by pickling, polishing, or sand blasting, as already described, and are then placed in a closed iron receptacle, charged with zinc dust and heated to a temperature of 500° F. to 600° F., for a few hours, and allowed to cool. The drum is then opened and the iron articles removed, when they are found to be coated with a homogeneous zinc covering, depending in thickness upon the temperature and the duration of the treatment.

Sherardising Plant. The zinc used in the process of sherardising is the ordinary zinc dust of commerce, the market price of which is about 20s. per ton lower than zinc ingots, or *virgin spelter*, as it is usually called. The process offers another important economy in that greasy articles can go straight into the sherardising drums without cleaning. The receptacle into which the zinc dust and the articles to be treated are placed is preferably airtight. The air is then exhausted, or if this be impracticable, carbon, in a fine state of subdivision, and to the proportion of 3 per cent. of the zinc dust, is added in order to prevent the formation of zinc oxide to an undesirable extent, as this dulls the appearance of the final coat. The usual type of receptacle employed is cylindrical, or polygonal in shape, arranged to be rotated or oscillated during the process of heating. The cylinder, when charged, is placed in the furnace, a cast-iron shell of suitable shape, with a series of Bunsen burners in its lower part. The receptacle is rotated or oscillated by hand power.

The coating given by the process of sherardising is brighter in its metallic lustre than that attained by electric deposition, although the spangled effect of hot galvanising cannot be imparted.

Continued

THE NURSE AND HER WORK

Nursing as a Career. Training and Prospects. The Home Nurse. Night and Day Duties. Preparation for Infectious Cases. Bed-making

By Mrs. ROBERT E. NOBLE

THE girl who is contemplating the career of a nurse for her life's work should count the cost carefully. The work, though interesting, is exceedingly arduous, and the physical and mental strain of service in the wards makes great demands on the nurse's strength and staying power. Many would-be nurses spoil their chances of attaining any high degree of success by a disadvantageous use of the years that must elapse between school and hospital training. A daily round of petty social duties, hours of idleness lengthening into two or three years without any definite work, totally unfit a girl for the strenuous and methodical routine of hospital work. Some daily task or study should be undertaken which will necessitate the cultivation of habits of punctuality, neatness, tact, and patience. These qualities are indispensable for successful work as a nurse, and must be acquired sooner or later by any girl who wishes to make headway in the profession.

How to Enter the Profession. The age for training varies slightly in various hospitals, the limit being usually from twenty-three to thirty-five. Some nurses begin their training at a lower age, spending a few years in a children's hospital until the necessary age for adult training is reached. Others study special subjects, such as the nursing of fevers, massage, etc., but more benefit is derived from these special courses if they are taken at the end rather than at the beginning of the full course.

Several months before the intending nurse wishes to begin her training she should write to a number of hospitals, and ask the matron for a copy of the rules for probationers. Having carefully studied the regulations, the next step is to obtain a personal interview with the matron of the particular hospital selected. This interview is of the greatest importance for the candidate for training, since the practised eye of the matron enables her to detect quickly the presence or absence of those qualities, physical, mental and moral, which are essential to the successful nurse. But, since standards of judgment vary considerably with the individual, an intending nurse who has made up her mind to work at the profession in a whole-hearted manner should not be disheartened if her first application does not meet with a satisfactory reception. If she is not strong enough for general training she may be able to take up some special branch, such as the nursing of children, massage, or midwifery.

Choice of a Hospital. When making her choice of a hospital at which to seek training, the candidate cannot be too careful. Many inferior institutions which cannot offer real training advertise for probationers. Such advertisements should be regarded with the greatest suspicion, for a really good training-school is never in want of applicants, and it is absolutely essential to train at a school which can confer a recognised certificate at the end of the course.

Many institutions have attached to them a preliminary training school, in which the probationer passes a few weeks before entering on her work in the wards. She is there taught, by means of lectures and practical work, elementary anatomy, physiology, hygiene, bandaging, the making of dressings, the use of instruments, sick-room cookery, housework, etc. With this useful preparatory knowledge, the probationer signs her agreement for three years' training and enters upon her full course.

The salary she earns depends upon the hospital she enters. For probationers, it varies from £8 to £15 a year, with board and lodging, and generally uniform. In a few cases the probationer pays for her training during a part or the whole of her course.

The Nurse's Ward Duties. Her work in the ward keeps her usually both busy and interested. At first the multifarious duties are confusing and fatiguing, but the methodical arrangement of the work lightens it as far as possible for all concerned. Then the exact times of entering on and leaving duty vary in each hospital, but punctuality is the first of all necessities. The nurse must not remain in the wards when off duty," neither must she visit other wards unless sent by someone in authority. She rises each morning about 6.30, and breakfasts about 7.15, being ready, after prayers, to go on duty in the wards at eight o'clock. During the morning the probationer will polish the metal-work of the ward, taps, etc., wash up the breakfast things, dust the ward, scrub the lockers and doctors' tables, and help with the patients' luncheon and dinner. In turn all the probationers go to their own dinner, having in most hospitals about three-quarters of an hour for the purpose.

Returning to their duty in the ward, the probationers clear away the dinner things, wash the knives and forks, make beds, dust and sweep the ward, and help with the patients' tea. Then, at about five o'clock, comes half an hour's interval for their own tea. During the evening they again make the patients' beds, help to wash the patients, serve supper, tidy up the ward, and prepare it for the night by making up fires, and so on. Then, after their own supper and prayers, they retire to their own rooms, and all lights are out by eleven o'clock.

The Probationer's Opportunities. This, in brief, is an account of the daily routine of the probationer nurse. Her work is hard, and every minute of her day is filled. But she has the advantage of associating with young women of her own age, with similar interests and ambitions. During her first year in the ward she does little actual nursing, but she has abundant opportunities for learning. Skilled nursing is going on around her; if she keeps her eyes and ears open, and is always on the alert, she will gain invaluable experience and a thorough insight into her work. As far as possible the nurses help the probationers by teaching them and by seeing that their allotted tasks are well performed.

The work of the nurses necessitates more skill than that of the probationers. The former watch and attend to the more critical cases, give medicines and stimulants under the supervision of the sister

of the ward, and assist with the general work of looking after patients and keeping the ward in order.

The nurse's salary varies from £18 to £30, with uniform. During their three years' course, nurses in training attend various lectures bearing on their work, on such subjects as physiology, anatomy, pharmacy, and dispensing. They take notes at these lectures, and attend weekly classes held by the sisters, in which further instruction is given. At the end of the various courses examinations are held, which each probationer is required to pass.

In turn, all the nurses are on "night duty." The whole of their daily routine is then changed, since they sleep between the hours of 1 and 8 p.m., and go on duty at about 9 o'clock in the evening, remaining there, with short intervals, until the return of the day nurses at 8 a.m. next morning.

Besides the necessary duties set apart for meals, all the day nurses have definite off-duty times each day. Probationers get a regular off-duty time of from one to three hours daily, with occasional half-days, and a whole day about once a month. The nurses get longer "off-duty" times; but, unless they have a special "pass" signed by the matron, every nurse is expected to be in hospital at 10 p.m. The annual holiday varies from two to four weeks, according to the seniority of the nurse in training. A probationer whose work is unsatisfactory may be required by the matron to withdraw without finishing her course, in which case no certificate is granted.

The Branches of the Profession. At the end of her full training, the nurse has various courses open to her. She may obtain a staff appointment, and remain at the hospital as staff nurse or sister. Many nurses proceed to study some special branch of nursing—mental, infectious cases, massage, midwifery—and find their additional knowledge invaluable when acquired at the conclusion of the three years' general training.

About two-thirds of the nurses trained take up private nursing at the conclusion of their hospital course, either working independently or associating themselves with the work of an institution. In the latter case, the nurse only gets, perhaps, a percentage on the money she earns; but she has a small and regular salary, and her risks are few. By the co-operative system a number of nurses combine together to minimise expenses, and the risk of having to refuse cases becomes less. The independent nurse is fortunate in retaining all the money she earns, but her risks are greater, and she may lose her connection by her inability to accept all the work offered. Many nurses "specialise" after leaving the hospital, although in the wards they all have experience of both medical and surgical nursing. Then a large number of nurses take service abroad, working chiefly under the Colonial Nursing Association as missionaries. Others take up district nursing, which includes the various ways in which the poor are nursed in their own homes. To carry on this phase of work successfully, the nurse must not only be skilful in her profession, but must also have a deep sympathy with the poor. She should be interested in the life and social condition of the people, and be prepared to work hard for a smaller remuneration than she would obtain in other branches of her work.

Poor-law nursing offers a good opening for an energetic nurse. Many of the various infirmaries and asylums have excellent training courses, but the nurse should carefully ascertain if the school is recognised and can confer a certificate.

Special Appointments. Nurses who have obtained full training in an adult hospital are eligible for appointments under the Local Government Board. These posts are very responsible, and give great scope for an energetic nurse who wishes to work her way up until she becomes matron of a large hospital. It is in an infirmary or asylum that the nurse has the opportunity of seeing the course and nursing of infectious diseases, etc.

During the last few years a number of training nurses have taken up naval and military nursing. For work in naval and military hospitals candidates must have been through the full training course in a general hospital. The rate of payment is good, varying from £30 for a sister to £200 for a lady-superintendent. In addition to these salaries the nurses are given furnished quarters and an allowance for fuel, light, and food.

Whatever work the trained nurse decides to adopt, she will find the three years' general training invaluable. The habits of neatness and methodical work acquired in the ward must be retained throughout her career. A slipshod nurse prohibits her own success, and in this, above all other professions, personal neatness and daintiness is essential.

The mental qualities of the nurse are very important. She must have plenty of patience and tact, and a keen insight into human nature. A quiet manner, accompanied by a firm but gentle attitude towards the patient, is very necessary.

It is absolutely necessary, too, that the nurse should have good health. Any particular form of physical weakness soon reveals itself under the strain of hospital life. A slight, short girl, of light weight, would find the effort of lifting and assisting heavy patients too great. The nurse's eyesight also should be strong, and her senses of smell and hearing perfect.

Given these conditions, a girl who is really interested in the work of tending the sick should find in hospital nursing admirable scope for her talents. She will not only have a healthy and interesting occupation, but will be acquiring skill which will ensure her a certain income, and may enable her to secure later in life an important and responsible appointment.

The Home Nurse. A good nurse will ever keep in mind that she has three distinct duties to perform—her duty to the patient, her duty to the doctor, and her duty to herself. Not one can she afford to neglect without affecting the others also. Her first duty is to aid in every possible way the recovery of the patient, and this can only be done by rigid obedience to the doctor's directions and attention to her own health. Towards the patient her attitude should be firm, yet kind and gentle. A dictatorial and overbearing manner is to be condemned in a sick-room, and the patient is far more likely to be persuaded to take food or medicine, or perform any other uncongenial task, if the nurse approaches the subject tactfully.

The home nurse should cultivate an even and cheerful temper. She must be very sympathetic, but must never allow complaints or criticisms of the doctor's treatment. She must bear in mind that confidence is a great factor in recovery, and her patient's chances of getting well soon are damaged when distrust of the doctor creeps in.

An observant and intelligent nurse is the doctor's most valuable helpmeet. She is constantly with the patient, and has, therefore, exceptional opportunities for noting slight changes in his

condition. The doctor only comes at intervals, and to a certain extent he is dependent upon the nurse's watchfulness and her accuracy in reporting details, however slight. It is always better to tell the doctor too much rather than too little: he can then sift the wheat from the chaff and make the most of all the information he has received. The nurse will do well to keep a careful record of all that happens between the doctor's visits, noting the patient's pulse, respiration, and temperature at given intervals, the amount and character of the patient's sleep, and any other records the doctor may wish to have.

The Doctor's Visit. It is one of the nurse's important duties to prepare for the doctor's visit. Everything should be in readiness for him, since his time is valuable, and it is exciting and worrying to the patient to see hasty preparations being made. Hot and cold water and a hand-basin should be ready for use, together with some antiseptic soap and clean towels. When the doctor arrives the nurse should, if possible, see him for a few moments in a room adjoining the sick-room. She can then give the doctor the record of the patient's state, telling him all she can of his condition since the previous visit. This should be done out of sight and hearing of the patient. She should be ready to take the doctor's thermometer after use, wash it carefully in some disinfectant solution, dry it carefully and replace it in its case, returning it to the doctor without shaking down the index. Any steel or silver instruments the doctor may have occasion to use she should clean in the same way, afterwards polishing them in a piece of leather before restoring them to him.

All semblance of fussiness in the sick-room is to be avoided.

The Nurse's Dress. In the matter of dress, the home nurse should exercise a careful choice. Simplicity should be the keynote to her costume. A plainly made frock, of serge in the winter and of some washing material in the summer, will be most suitable. In nursing an infectious case a washing material should invariably be chosen. The dress should be made sufficiently loose to allow of perfect freedom of movement. The skirt should be made short enough to clear the ground. She can then have long cuffs and sleevelets, kept up by elastic, that can be taken off while work is performed that long sleeves would hinder.

In matters of personal cleanliness and neatness the nurse cannot be too careful. There is nothing more depressing to the patient than a dirty, slovenly, untidy nurse. She should choose colours that are restful to the eye, blue and grey materials, and her large apron should always be fastened neatly and be spot'ess. It should be provided with a wide bib held up by straps passing over the shoulder, crossing behind and fastening at the waistband. The apron itself should be large enough to well cover the skirt, both long and wide. It should be furnished with a large, deep pocket, in which the nurse should keep in readiness her scissors, keys, etc. On her feet she should wear well-fitting, moderately loose shoes or boots. These should have low heels and fairly strong soles. Special ward shoes are now made for nurses, sometimes with rubber soles and heels. Many of these are excellent, and can be adopted for wear by the home nurse for her comfort and that of her patient.

In choosing her other garments the nurse should have due regard to warmth, lightness and comfort Well-fitting clothes, with wool or silk next the skin, are a sine qua non. Woollen stockings should also be worn, since cotton lead to much discomfort if the feet get hot and tired.

Hospital nurses complete the attractive simplicity of their dress by wearing small caps on their heads, and their example may be followed by the home nurse who knows how to dress her hair with the necessary simplicity. Personal ornaments of all kinds should be banished from the sick-room.

The Importance of Regular Meals. Good health is only compatible with a proper amount of good food. The nurse should make every effort to take her meals regularly. If her work for the patient is carried out unaided, she should contrive carefully to leave him asleep or comfortable while she gets her own meals. These should not be hurried over, and she should, as far as possible, avoid both the haste and the kinds of food that are likely to produce indigestion. After the night's rest the nurse should take a light meal, such as a cup of tea and a slice of bread-and-butter, before entering on her daily round. It is especially important to avoid entering the sick-room fasting if the patient is suffering from an infectious disease.

As a general rule, the nurse should take all her meals away from the sick-room and out of sight of the patient. They should be light and nourishing. Stimulants and excessive tea-drinking should be avoided. The work of a sick-room is exhausting, and necessitates a certain amount of strain. This is, however, best counteracted by plenty of nourishing food, suitable exercise, and sleep.

Successful nursing cannot be carried out with insufficient sleep. A full seven hours is essential. The nurse's nights will be broken and often lost, and she will therefore do well to arrange, if possible, to sleep between 2 p.m. and 9 p.m. Between these hours, by skilful management, she can generally be spared from the sick-room. Most of the essential offices for the patient, washing, and meals have been carried out in the morning, so during the afternoon there will only be his tea to prepare, and a few lighter duties, which can generally be entrusted to a willing helper. It should be remembered that the mental freshness and alertness of the nurse react on the patient.

Personal Details. The nurse should sleep in a well-ventilated, darkened room. She must be careful for the sake of her general health to indulge in a daily bath, or, better still, two—cold early in the morning and warm before retiring to sleep. The usual details of the toilet should be particularly carefully attended to.

Exercise is also an important point for the home nurse to consider. Without it she will not enjoy refreshing sleep and a healthy appetite, and so her work will suffer. A few minutes may, with advantage, be spent in the open air both morning and evening, and a brisk walk for a minimum of half an hour is indispensable to good health. The nurse who has her patient's mental as well as physical welfare at heart will be quick to relate anything interesting she may have seen or heard in these daily outings, so that the patient will come to look forward to her return for a pleasant chat and a renewal of interest in the outside world. Without this the atmosphere of the sick-room may easily become dull and depressing, and the nurse must always bear in mind that cheerfulness is closely associated with skill and sympathy in bringing about the recovery of the patient.

The sick-room should, of course, be chosen with the greatest care. Where a choice is possible it should fall on the brightest and quietest

room in the house. It should be bright, since recovery is retarded in a sunless room. The room should be quiet, as sleep is an essential factor in recovery, and the trivial and generally unavoidable noises of the average household are annoying to an invalid. But, on the other hand, it is difficult to impose such restraint on every member of a household that no doors shall be banged and no loud voices heard for a long period. Such conditions are quite impracticable where there are children, and even in an adult household there will be moments of forgetfulness, and the irksome quiet will be disturbed.

For these reasons a room at or near the top of the house is generally preferable to those nearer the ground floor. In the case of an infectious disease it is almost essential to put the patient in such a room.

The room chosen should be airy and lofty. The room should be provided with a fireplace and a window that will open top and bottom. A casement window is not desirable in a sick-room, since it makes the regulation of the incoming air very difficult; a sash window is more easily managed and more conducive to adequate ventilation. The chimney greatly assists in ventilation; the fireplace should be free, and the "register" open, to allow of the escape of vitiated air through it. A small fire is always useful in a sick-room. It may be used to burn scraps of rubbish, dressings, and such-like, that might become sources of infection unless destroyed by fire. It also creates a draught, the current of warm air passing up the chimney and drawing after it the air of the sick-room that has been exhausted by breathing and contaminated by contact with a sick person. If the weather is too hot to admit of a fire, a small lamp placed in the grate will act beneficially in producing the desired draught.

Infectious Disease. In the case of infectious disease, it is of the greatest importance that the room chosen should be near the top of the house and away from parts much frequented by other members of the family. Hot air rises, so that the draught in a house is towards the upper parts, especially if a window on the top landing is kept open a few inches. Thus disease germs escaping from the sick-room will not be drawn into the house if an upper room is selected for the use of the patient.

Carpets and woollen curtains must be banished from the room, also upholstered chairs, but the room should be arranged to look cheerful, because during the long convalescence and isolation entailed by an infectious complaint the patient is very prone to depression.

The nurse must be careful not to leave food—particularly milk—exposed to the air of the sick-room, as germs are so quickly absorbed. All dirt should be disinfected and burnt, and the dishes used by the patient disinfected before being returned to the kitchen.

The sick-room, if possible, should face south, south-west, or west. The early morning light will in all probability disturb the invalid, and shorten his hours of sleep, and if attempts are made to exclude it, they can only be successful at the expense of fresh air and efficient ventilation. On the other hand, the bright afternoon sunshine, and particularly the last gleam before the sunsets, are invaluable in cheering the invalid. The afternoon is often tedious, and a little depressing to a sick person, and this last glow of the sun is cheering in its influence.

The ceiling, walls, and floor must be carefully dusted. All the woodwork should then be wiped over with a damp cloth, which is kept moist by a little hot water, to which an antiseptic has been added. The fire should be lighted, and the temperature of the room allowed to reach about 60° F.

The room should be uncarpeted, and all unnecessary furniture removed. In nursing an infectious disease, this banishing of all upholstered furniture and carpets is indispensable. To give an air of comfort to the room, strips of carpet or rugs may be used, since they can be so easily taken up and shaken and replaced.

Ventilation and Temperature. For simple means of ventilation, see Health, page 4019.

A good nurse will make the temperature and ventilation of the sick-room the subject of very careful study. The temperature usually ordered for the sick-room is from 60° to 70° F., and with a little care the standard can be kept up, so that within the twenty-four hours the variation will only be two or three degrees. A well-made thermometer is necessary for this purpose, and should be hung near the patient, somewhere near the level of his head.

The fire-irons should be taken away from the room. If left in the grate they are likely to slip and disturb the patient, or the nurse, however careful she may be, may accidentally catch them with her skirt and cause them to fall with a clatter that will jar upon the patient's nerves. An old walking-stick will make an efficient substitute for a poker. A little sand should be powdered over the hearth to deaden the sound of the falling ashes, and the coal should be packed before it is sent to the sick-room in paper bags, each one containing about 2 lb. of coal. By this means the nurse can noiselessly replenish the fire, without the use of tongs and without incurring the risk of soiling the hands. It is in the early morning, between 1 a.m. and 5 a.m., that the nurse will find the vitality of the patient at its lowest ebb. He will then be in a condition to feel the cold more, and she should cover him with an extra blanket, and be careful to replenish the fire lest it should burn low and the room get chilly as a result. She will then find it a great advantage to be able to make up the fire quietly, as the patient is very likely to be sleeping at that hour, and, if disturbed, he might not find it easy to sleep soundly again.

The Bed. The choice of a suitable bed is of very great importance. Generally speaking, a wide bed is a disadvantage, since the nurse has the additional strain of doing everything for the patient at arm's length. The solitary advantage offered by the wide bed is that the patient can use one side during the day and the other at night, thus obtaining the necessary coolness and freshness which is so conducive to rest.

A small iron bedstead, with a light but strong frame, resting on castors that make it possible for the bed to be moved without shaking the patient at all, is the ideal one. The length of the bed should be about 6 ft. 6 in., and its width either 3 ft. or 3 ft. 6 in., and it should be fitted with a strong chain mattress. The chain mattress should be covered by a good hair mattress to give the necessary "spring." Sometimes bran and hay mattresses are used. These offer the advantage that, should they get wet or soiled, the covers, which should be made detachable, can be removed and washed and refilled quite quickly and easily, and with practically no expense.

The bed should be placed between the door and fireplace, if possible near the middle of the room, and it should, unless the smallness of the room prohibits it, be allowed to stand clear of the walls and other furniture, so that it has around it in all directions a space of at least 2 ft.

The advantage of this is obvious. It permits of the free circulation of the air round the bed, and enables the nurse to approach the patient easily from either side.

Care should be taken to see that the bed is not so arranged that the patient is facing the light. In some complaints the effect of direct sunlight on the eyes is very injurious. In measles, for example, the eyes are abnormally weak and susceptible to injurious influences, and in cases of brain trouble or affections of the eyes similar precautions are necessary to prevent the light from producing unnecessary strain or injury.

The nurse will find that it is often very advantageous to have a second bed in the sick-room. If the patient is well enough to stand the exertion of being moved, he will benefit greatly by the use of one bed during the day and the other at night. His sleep will be more easily induced, and much more refreshing under these conditions.

In choosing the sick-room care should be taken to select a room in which the wallpaper is soft in colour, with a restful pattern.

Night in the Sick-room. It is of the greatest importance that the patient should have an abundance of sleep, and to secure this the nurse should take every precaution possible. Once the patient has settled down for the night she must be absolutely quiet and on no account rouse him from his first sleep. First of all she should sponge the patient's face and hands with warm water and change his nightshirt. His bed must be either remade or at any rate made comfortable, and it is a good plan to give him a fresh pillow. The fire should be made up for the night, and a supply of coal in small paper bags should be put in readiness. Some light, warm food should be prepared for the patient and given the last thing before he settles down to sleep.

The character of the patient's last meal will, of course, depend upon the complaint from which he is suffering. In any case it should not be cold, as that is likely to keep him awake, and it should be digestible food, such as a glass of warm milk or a cup of beef tea. The nurse herself should take a good meal just before preparing the patient for the night. It will then be unnecessary to disturb the patient during the night. In the early morning, at about five o'clock, she will probably find that he will be glad of a light meal, perhaps a cup of tea and some bread-and-butter.

The Nurse's Night Duties. The nurse should provide herself with a comfortable easy chair and some noiseless occupation if she is to keep watch during the night. As a rule, it is well for her not to read, or she may become drowsy and inadvertently fall asleep. Her occupation must, however, be silent, as many a nervous patient has been kept awake by the click of a knitting-needle or the rasp of a thimble.

The nurse must place the lamp so that the light is screened from the patient's face, and her chair so that she can see every movement on the part of the patient without giving him the impression that he is under such close observation. By skilful arrangement of mirrors the nurse can often see the patient distinctly in a glass when she is apparently with her back turned towards him.

Whilst the patient is asleep the nurse should make careful notes of his condition and any changes in it. She should note down in writing the exact amount and character of the sleep enjoyed. She should notice exactly how much sleep the patient gets. The character of the sleep should also be noticed, and whether he awakes refreshed or otherwise. She should state also whether the sleep is sound, broken by dreams, or talking, or movements.

When the doctor has ordered medicine to be given every two hours the nurse should be careful to ascertain from him if she is to wake the patient to administer it. It may happen that the prolonged sleep of the patient is merely a sign of extreme exhaustion, in which case it is of the utmost importance that he should be roused at stated intervals for medicine and nourishment.

If the patient is wakeful it is sometimes a good plan to take away his hot pillow and give him a cool one rather than to turn the same many times. An extra pillow is also useful in many cases. For example, in nursing pneumonia the patient may be so weak that he slips over on to his back instead of resting on the affected side. In this case a pillow against his back will give valuable support. Then in nursing cases of abdominal disease a pillow under the patient's knees will enable him to relax the muscles which otherwise exert a painful pressure upon the abdomen. Also, a rheumatic patient finds the pain in the knee joints eased if they are raised on a soft feather cushion.

The moment the patient awakes the nurse should have either medicine or warm food in readiness for him, after which he will probably fall asleep again. Gentle friction of the patient's back and limbs may induce sleep in a restless patient, and the friction must be continued for a short time after the desired effect has been produced, or its cessation may awake him.

How to Prevent Bed-sores. The nurse must be constantly on the watch for bed-sores, as they form easily and are cured with difficulty. Speaking generally, a bed-sore is regarded as a sign that the nursing has been neglectful, but this is not an infallible rule, for they are occasionally merely signs of extreme debility in the patient. They most readily make their appearance on projecting parts of the body that press on the bed, such as the base of the spine, the shoulder-blades, and calves.

Certain parts of the skin become bright red, and every part of the body should be daily examined during a long illness for these unwelcome signs.

At the least sign of redness the part affected should be washed night and morning with soap and water, thoroughly dried, and rubbed with eau-de-Cologne or a little good whisky until the skin is dry. Methylated spirit will serve the purpose. Should the patient perspire freely the skin should be powdered with a mixture of equal parts of zinc oxide and starch.

An air pillow should be used to support the affected part, and it should be shaped with a hole in the middle to diminish the pressure on the part where a bed-sore is impending.

A small dressing, the exact size of the bed-sore, is applied. A piece of lint wrung out in carbolic oil may be used, or boric-acid ointment, or resin ointment. Over this a larger piece of lint spread with vaseline is applied, and the whole kept in position by means of strips of adhesive plaster. A solution of silver nitrate will harden the skin, but it has the disadvantage of blackening it also. The alternative treatment before the skin is actually broken is to paint it with collodion.

Care must be taken in fixing the dressing to attach strapping or plaster to parts of the skin some distance from the bed-sore.

In very severe cases bed-sores make their appearance on parts of the body where no pressure exists—for example, on the front of the thigh. These sores are the result of loss of tone in the blood-vessels

of the skin. The treatment in this case is heat and cold applied alternately. A small piece of ice is wrapped up in flannel and held to the part affected for about ten minutes until the skin is pale; this is followed by the application of a sponge wrung out in very hot water until the skin is hot and red. Absorbent cotton-wool should be used to remove the moisture and powdered boracic acid applied.

Visitors. No visitors should be allowed in the sick-room when the case is infectious. The nurse should find out from the doctor exactly how many visitors it will be safe to admit. They should be only allowed to come at stated times and to stay as long as is not harmful to the patient. The visitor should not enter the room suddenly, as the shock might be bad for the patient. On the other hand, he should not delay his coming once the patient knows that he is expected, as the waiting is also bad for the nerves. The visitor should never lean against the bed or jerk it, but should sit in a position in which the patient can see him clearly. He should not stay long, and should leave without any indecision. The patient should be given some light food soon after the visitor's departure, and the nurse should notice whether the visit has unduly excited or depressed him.

Under certain circumstances the patient will perhaps complain of the pressure of the bed-clothes on sensitive parts of the body. For example, after an abdominal operation, or in cases of rheumatic fever, the weight of the bed-clothes on the affected parts will cause unnecessary suffering. If the bedstead have bedposts, this pressure may be relieved by passing a strong piece of string under the bed-clothes diagonally and tying it to the posts of the bed. By this means, if they are well tucked in each side under the mattress, and fastened with safety pins top and bottom, he will be kept warm without feeling the weight of the clothes.

A small bed-cradle is sometimes necessary to keep the weight off a limb. A satisfactory substitute for a cradle may be made by cutting a tunnel through an ordinary bandbox.

In long and tedious diseases the patient is inclined to slip to the bottom of the bed. This may be prevented by slightly raising the foot of the bed by wooden blocks under the castors. In heart disease the patient will tend constantly to slip down low in the bed, especially during sleep. This position is very bad for him, as it renders breathing more difficult.

When he is still weak, but well enough to move his hands and arms, it is a good plan to tie a piece of rope with a loose end to the foot of the bed, by means of which the patient can raise himself or can get assistance in turning.

The Convalescent. The nurse must always be on the alert, when the patient is recovering to detect any change for the worse. There is always the risk of a relapse, and complications of the disease may set in at any time. In some cases special precautions must be taken. For example, attention must in some cases be given to the diet, that it may be not only digestible, but that no foods are included that might prove dangerous.

The convalescent must be well protected against draughts and cold. He should wear a flannel bed-jacket, buttoned up to the chin, with long sleeves, whenever he sits up in bed or is occupied in some way that uncovers his arms and chest.

Great attention must be paid to the convalescent's diet. It should be both abundant and nourishing, for he has not only to build up fresh tissue, but to repair the waste due to the ravages of disease. All indigestible foods should be avoided, but, subject to the doctor's directions, the patient's fancies should be humoured. With returning health the appetite improves, and, if the food is served daintily, and carefully prepared, he will welcome his meals. Light food, such as soup and milk puddings, may be abundantly given.

The nurse should watch the patient carefully, lest he overtires himself. After long weeks of inactivity he will be too ready to over-exert himself and to over-rate his slowly returning strength. He should sleep for nine or ten hours every night, and a short rest during the daytime, after each meal, will hasten his entire recovery.

Cleaning the Sick-room. The sick-room must be kept scrupulously clean. It is the nurse's duty either to see that the necessary cleaning is done properly, or, in some cases, to do it herself. Every morning the hearth must be quietly tidied, and the ashes collected. If the disease being nursed is infectious, a disinfectant should be poured over the dust and ashes before they are taken from the sick-room. The floor must then be well swept. If this is done slowly and gently there is no need for a cloud of dust to arise and cause discomfort to the patient. The best plan is to roll up the strips of carpet or rug on the floor and then to sweep up the dust towards the centre of the room, to avoid bringing some of the dust the whole length of the room. Another satisfactory method is to sweep towards the fireplace, and take up the dust in the grate and burn it straightaway in the fire. This is one of the many little ways in which a fire in the sick-room will be useful for other purposes besides that of heating. Should there be no fire, it is a good plan to take up all dust and fluff after sweeping it together by means of a damp cloth.

The sweeping process must be followed by that of dusting, and the whole room should be thoroughly wiped over with a duster at least once a day. All furniture should be removed with the exception of the bed. The woodwork of the room—door, skirting, window sills, etc.—should be wiped over daily with a damp cloth wrung out in a dilute solution of some antiseptic fluid. The latter should preferably be a fluid free from characteristic smell, as that is likely to cause discomfort to the patient by affecting the air of the room. A careful nurse will leave no part of the sick-room undusted; the tops of picture-frames and screens, the legs of the chairs and tables, window-ledges, and medicine bottles, will one and all be freed from every trace of dust and dirt. The windows of the sick-room should be kept bright and clean. Nothing is more depressing that the dull outlook of a room with smeared or dirty window panes.

The Patient's Bed. The bed-clothes should be chosen with care. The mattress should be covered with a light woollen or cotton sheet. Linen is unsuitable, as its surface is cold and likely to chill the patient, but, as in the case of the use or discarding of a feather bed, the ordinary habit of the person concerned must be taken into account, and no abrupt change brought about. The use of an under blanket beneath the sheet is not desirable for ordinary patients. In some cases it may be used with advantage, as in very cold weather, but, generally speaking, it is better to dispense with it. It tends to wrinkle, and so to produce the irritation which encourages bed-sores. In nursing cases of acute rheumatism it is necessary to place the patient in a blanket with no under-sheet, but this is an exceptional case. Blankets absorb the perspiration from the

body, and become moist, and so predispose the skin to bed-sores. Sheets are therefore preferable.

The under bed-clothes should be spread quite smoothly over the mattress, and well tucked in; if an under-blanket is used it should be wide enough to tuck in tightly. The upper bed-clothes should also be of suitable width, and tucked in well; if too narrow they will be a constant source of discomfort. The warmth of the bed should be secured by the use of plenty of thick new blankets or blankets that have not been washed, as washing tends to make them thin. The maximum warmth should be obtained with the minimum weight over the patient. In any case the weight of the bed-clothes should be carefully distributed, so that there is as little pressure on the patient's chest as possible, and the greatest weight over his feet. The ordinary counterpane should not be used: it is too heavy and too closely woven for health. The pressure so produced may seriously interfere with the patient's breathing and the same ill-effects are caused by bed-clothes that are too heavy. An excellent substitute for a counterpane is a clean sheet folded and used at half its width as a counterpane. The whiteness is very attractive, and clean-looking, and lends to the bed and room a cleanly and cheerful appearance.

The patient should be provided with at least two soft pillows, well beaten up whenever the bed is made, and at other intervals during the day. Two pillows are more comfortable than a pillow and a bolster, as they are more easily turned and smoothed. The nurse will find that the patient's sleep will, to a great extent, depend upon the comfortable nature of his pillows; if too high, they will make him suffer from stiffness of the neck and shoulders, and if too low, they will be an incentive to headache and restlessness generally.

The Draw-sheet. The draw-sheet is an essential addition to the bed of a patient suffering from some complaint that necessitates many turns in bed. It is easily prepared by folding an ordinary sheet along its length until the folds are only one-third or one-quarter the ordinary width of the extended sheet. Thus, the sheet is reduced in width, its length is unaltered, and it presents two or three thicknesses. The bed is made in the ordinary way by spreading an under-sheet as smoothly as possible over the mattress. Over this the draw-sheet is laid. It is placed so that the greatest length goes down the bed. On one side, just enough of the folded sheet is used to tuck in firmly, and the excess on the other side is rolled up into a smooth roll, which is placed under the mattress. Sometimes safety pins are used to secure the draw-sheet in position.

The draw-sheet is placed across the bed so that, when the patient is on it, it will extend from about the length of his armpits to his knees. The advantage is obvious. Suppose that for any reason the draw-sheet becomes soiled or damp, as when poultices are in use; if there is no draw-sheet, the undersheet would have to be changed, giving much trouble. If, however, there is a draw-sheet, the remedy is easily applied. The tucked-in side of the draw-sheet is rolled up towards the patient. The clean roll is then loosened. The patient is gently raised by the nurse by a kind of leverage movement of her arms when placed under his shoulders and just above his knees. The assistant then draws the roll of soiled draw-sheet towards her in such a way that a fresh length of the clean roll now rests beneath the patient. This process may, with advantage be gone through two or three times every day, the sensation of cool comfort being very soothing to the patient. In nursing some cases, it is advisable to place a slip of double-faced macintosh between the under-sheet and the draw-sheet. It should be securely fastened in position by safety pins, attaching it to the mattress. The draw-sheet should overlap the macintosh by 6 in. or 8 in., for if the macintosh should come in contact with the patient, it may be a source of trouble in the form of bed-sores.

How to Change the Upper Sheet. The upper bed-clothes should be untucked all round, and one of the patient's pillows temporarily removed, so that he will lie more flat on the bed. The upper blanket is then taken off, and the clean sheet, which has previously been well aired and warmed, is spread over the bed. Over this the upper blanket, which has been removed, is placed, so that the patient is covered by four layers of covering, soiled sheet and second blanket, over which is placed the clean sheet and upper blanket. The lower layers have to be removed, so that the clean sheet and blanket will cover the patient. The nurse will need assistance in the interchange of sheets. The assistant should stand at the head of the bed and hold the clean sheet and upper blanket firmly, one hand being placed on either side of the patient's head at about the level of his shoulders. The nurse should stand at the foot of the bed and, using both hands, placed well apart from each other, steadily draw out the soiled sheet and its accompanying blanket. In doing this she must take great care not to raise her arms, for then the cold air will rush into the bed and chill the patient. The withdrawn blanket can then be placed over the bed, now taking the position of upper blankets, and then the bed-clothes should be tucked in as before. If necessary, the process may be carried out across the width of the bed instead. In this case, the nurse and her assistant will stand on either side of the bed and the sheet be withdrawn at the side instead of from the bottom. By either of these processes, the clean upper sheet is put in position with little or no difficulty, and with the minimum exertion to the patient.

Changing the Lower Sheet. The clean sheet, which is to replace the soiled upper one, should be well aired and warmed, and then rolled lengthways for half its width, and placed on a chair in readiness. The bed-clothes should then be untucked and the upper ones so arranged that the free edges of sheet and blanket are folded back out of the way. The draw-sheet and macintosh are then unpinned and rolled up towards the patient for a few inches. The assistant stands on the opposite side of the bed, and, holding the draw-sheet and macintosh securely, she should, by means of them, gently turn the patient on his side, so that half the soiled sheet is free. From her side of the bed, the nurse then quickly rolls this up lengthways till it lies in a roll down the middle of the bed. She then takes the clean sheet and places the clean roll beside the soiled one, and carefully smooths the unrolled part of the clean sheet over her half of the bed, tucking it in securely, and seeing that the sheet is arranged straight and without wrinkles.

The assistant hands her the draw-sheet and macintosh, and the nurse first gently lowers the patient so that he lies across the two rolls. She then pins the macintosh and tucks in the draw-sheet on her side of the bed. The assistant meanwhile takes out her roll of draw-sheet and macintosh. The nurse holds this with both hands, placed not too near together, and uses the draw-sheet gently to turn the patient on to his side so that he faces her. In doing so, he passes over the

two rolls and now puts on the clean sheet. The assistant then quickly draws away the soiled sheet and unrolls the remaining half of the clean one and spreads it smoothly over the bed and tucks it in. Then she takes the draw-sheet roll from the nurse, allows the patient once more to be on his back, and secures the macintosh and draw-sheet in position. The patient is now lying on the clean sheet, which has replaced the dirty one without being unduly fatigued.

If the nurse is obliged to do the work single-handed, she will find it is best to work from the bottom of the bed to the top, instead of from side to side. She can easily roll up the soiled sheet to the level of the patient's back, and replace it with the clean sheet, which has been previously rolled up to half its length. Then using her right arm to support the patient, she can raise him enough to roll up or push aside the soiled sheet and unroll the clean one to take its place.

The edges of the clean and soiled one should be pinned together, and while the nurse raises the middle of the patient's body the assistant should gently pull the soiled draw-sheet towards her, till the clean one is in the right position beneath the patient. If the patient is very heavy, it is advisable to change the draw-sheet in the same way as the under-sheet, as this obviates the necessity of lifting him.

Changing the Patient's Night Shirt. The clean night shirt or night dress should be well aired and warmed and put in readiness for use. Then the patient should be raised slightly in the bed, and his night shirt freed from the weight of his body, and unbuttoned. The arm near the nurse should be withdrawn from the sleeve, and the soiled night shirt drawn up to form a roll over the patient's chest and shoulders. Care must be taken not to allow the cold air to come into contact with the patient. Then the nurse should hold the clean night shirt over her wrists and forearms by passing her hands *downwards* through the collar and front, and out at the bottom. She then passes her hands *upwards* through the bottom of the soiled shirt, and out through its collar. By the same movement she gets the clean night shirt over the patient's head and quietly slips away the soiled one. It is then an easy matter to slip the patient's arms into the sleeves, to fasten the buttons, and to raise the patient to draw the night shirt smoothly into its position.

If the patient cannot sit up, the night shirt must be split up the back as far as the collar. The soiled one can then be withdrawn without disturbing the patient, and the clean one arranged to replace it. The free edges should be tucked down on either side, so that he is not cold. The night shirt should be changed night and morning, unless the condition of the patient is so serious that the doctor has ordered otherwise.

The Invalid's Meals. The nurse should consider herself responsible for the arrangement of the patient's meals. Although she may not actually prepare them herself, she should be sufficiently skilled in the culinary art to supervise its preparation. She must always bear in mind that an invalid's appetite is capricious, and that within the limits of strict obedience to the doctor's orders and the dictates of common-sense she should humour the patient's personal wishes and fancies.

Invalid cookery is a branch of the culinary art apart from the preparation of more solid meals. The food must be well cooked and digestible, and so prepared that with the minimum exertion the patient takes the maximum amount of nutriment. Food values must be carefully taken into account, and innutritive articles of food discarded for those that are more valuable as components of a nutritious diet.

In many cases the actual food to be given will be prescribed by the doctor, in severe cases even the amount being specified. These orders must be adhered to rigidly. It sometimes happens that even a slight deviation from the prescribed dietary will bring about a serious relapse.

How to Serve the Meals. A bed-table is a great convenience in the sick-room, either one of the elaborate forms now obtainable at varying costs or of a more simple character, consisting of a flat surface of wood supported on four short legs. The front edge of the wood is hollowed out to form a cavity, into which the invalid's chest can fit. Such a table will stand quite firmly on the bed if its legs are made to rest securely among the bed-clothes.

The meals should be brought up on a little tray covered with a spotlessly white cloth or serviette. The cutlery and glass used should be well polished and glistening and the cruet neatly arranged. All preparations should be made out of sight and hearing of the patient. If he has time to think about any particular food he may refuse to eat it when it appears. It is a mistake to ask the patient if he fancies any special food unless it is at hand for him. During the delay he is quite likely to change his mind.

The food should be served daintily and in small quantities. Food that is supposed to be hot should be really hot, not lukewarm, and everything should be properly flavoured before being served.

After the patient has eaten, anything that remains should at once be taken away. The doctor's orders should be asked for as to whether the patient is to be roused from sleep in order to eat. Sometimes the prolonged sleep may be a sign of exhaustion following great weakness, and in such a case the doctor will order the nurse to rouse the patient at fixed intervals in order to give him food. Sometimes the patient's disinclination to take food is merely a sign that he cannot digest it. In this case a fast of a few hours will not do harm, and may do a great deal of good in enabling the digestive organs to right themselves. If eating is generally followed by an attack of sickness then the nurse should give very small quantities of barley-water or milk, letting the patient take a few drops only at a time, in sips from a teaspoon or from a feeding-cup.

Administering the Medicine. The nurse should keep the medicine bottles in a little cupboard where they will not continually remind the patient of his unpleasant duty with regard to them. The nurse should use a graduated medicine glass to measure the medicines, and be careful to administer the exact dose. A small inaccuracy often repeated may lead to serious results. If the medicine is to be given three times a day, it is administered at 10 a.m., 2 p.m., and 6 p.m.; if every four hours, the additional dose is taken before breakfast. Medicines ordered for every six hours are taken at 12 and 6 o'clock both day and night. The nurse should always find out if she is to wake the patient to give him medicine. Medicines taken before meals are generally intended to assist the appetite and digestion and should be administered about ten minutes prior to the meal.

Continued

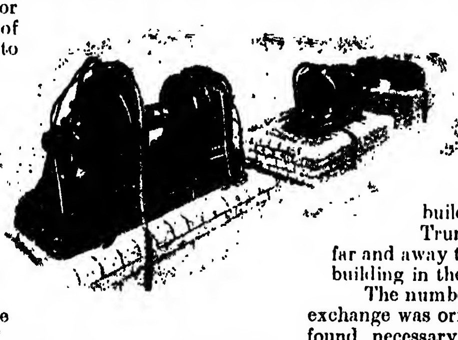
TELEPHONE TRAFFIC MARVELS

London's Huge Central Exchange. Eighty Thousand Wires in One Building. Trunk Working

Continued from page 6080

By D. H. KENNEDY

THE central energy system is a very good instance of the application of the adage inculcated by Mr. Carnegie—namely, to "put all the eggs in one basket, and watch that basket." Elaborate arrangements are made to secure from any possibility of breakdown the central source of energy. Usually, energy is obtained from the local municipality or supply company, and by means of a magneto generator transformed to continuous current at a voltage of 30. On the left in 27 can be seen the No. 1 generator, with its coupled motor, as used at the Ealing Exchange. The generator has six poles, and the commutator has a very large number of segments (176), the object being to secure that the top of the current wave shall be practically flat. The motor receives current from the municipality at 105 volts alternating. The combination is designed to supply from the generator side a maximum current of 200 amperes. In order to secure immunity from breakdown, a duplicate set (No. 2) is provided, and made, as far as possible, independent of No. 1. Where circumstances allow of it the stand-by motor-generator is served from the mains of a separate company, so that even in the case of a general breakdown of one company the exchange can still be worked.



27. MOTOR-GENERATORS FOR CHARGING

Near the door of the power-room can be seen the ringing machines, two of which are mounted on one bed; the same complete duplication of plant is carried out in this case. The feeder cables from the generators are carried through a power switchboard, and thence to the accumulator room [28]. Here, again, the same duplication is in evidence, two complete sets of eleven cells being provided. They are of the Chloride pattern, and have a total ultimate capacity of 2,000 ampere hours. During the early period of the exchange development only seven plates are installed, the remainder of the cells being shut off by a lead partition, and as the need arises additional plates can be added until the full capacity is absorbed. At the near end of the cells the main fuses are in view, and along the sides of the cells can be seen the leads which go through each cell to a voltmeter fixed upon the power switchboard by means of which the individual voltages can be read by turning a twelve-position switch. The fifteen smaller cells visible between the windows are used in connection with the meters, as these instruments require 30 volts. It should also be noted that the special design of the generators makes it possible to work the exchange direct without the interposition of the accumulators.

82. ACCUMULATOR ROOM

The London Central Telephone Exchange. Truly startling in the matter of telephone development has been the experience of the Post Office in the City of London. In April, 1902, was opened the new Central Exchange in Carter Lane under the shadow of St. Paul's. It was arranged for an immediate installation of 5,000 subscribers, and with an ultimate equipment of 14,400. Within three years it had not only become necessary to complete the equipment of the exchange up to its entire capacity, but, in addition, a second exchange with a capacity of 18,000 subscribers had been designed, and at the present time is completed and in operation, so that in this one building there is equipment for over 30,000 subscribers. The accompanying junction equipment involves an additional 3,000 pairs of wires, and the same building also houses the London Trunk Exchange, so that it is far and away the most important telephone building in the world.

The number of cable ducts entering the exchange was originally 110, but it has been found necessary to increase these to 214. Paper-insulated, lead-covered cables were exclusively used for the subscribers' lines. The original types were 2⅝ in. in diameter, and contained 434 wires for 217 subscribers. In the meantime, however, great advances in cable-making have been made, and many of these 217 pair cables have been supplanted by cables of the same external diameter, but containing 606 pairs of wires—that is, the capacity of the ducts has been practically trebled.

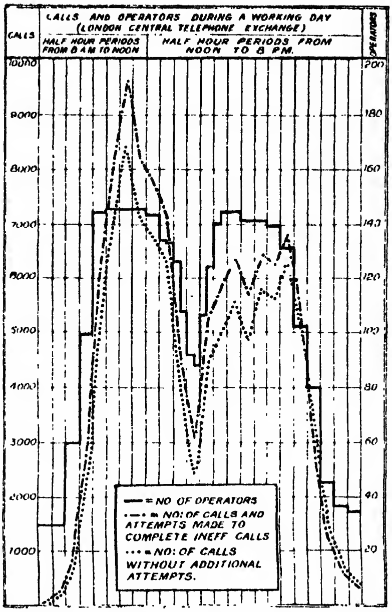
The cables are led into the sub-basement, where they are connected to the silk and cotton cables, which are led on to the main frame. From this point they are carried up a special cable chute to the third and fourth floors, where the intermediate distribution frames, relay and meter racks, and the switchboards are situated. In the original central installation, twenty-six subscribers' sections and sixteen junction sections were provided, completely equipped with multiple, so that each subscriber's line was connected to no less than forty-two jacks in the multiple, making with the answering jack, a total of forty-three. When it is

remembered that three wires are led *to* and three wires *from* each jack, it will be seen that the number of soldered joints on each subscriber's line was approximately 300. This goes a long way towards explaining what many regard as paradoxical—namely, that as the number of subscribers at an exchange increases, so does the cost per subscriber. The number of operators' positions at these sections was 126.

When the installation of the second exchange equipment was contemplated, a careful study was made of the number of transactions completed on the multiple, as compared with the number of outgoing junction transactions. It was found that only 1 in 5, or 20 per cent. of the calls were for Central subscribers, and, as a result, it was found more economical to dispense with the multiple on the subscribers' sections ("A" positions), its place being taken by an addition to the number of "B" positions. Subsequent experience has fully justified the wisdom of this change, which at one and the same time greatly reduced the capital expenditure and cost of maintenance, and simplified the operating in that it eliminated the less frequent type of call, so that all calls, whether for the Central or other exchanges, were dealt with in precisely the same manner. The number of direct lines now connected to this exchange exceeds 14,000; many of these lines serve more than one station, so that the total number of stations exceeds 20,000, the total number of operating employes being 414.

Traffic Studies. In order properly to proportion the staff to the work in a large exchange, a most careful study of the traffic is necessary. This is, of course, greatly facilitated by the position meters, and the extent to which such study is carried out can be best shown by actual figures, which relate to the Central Exchange, and refer to the 22nd day of March, 1907. In the diagram at the top of this page is depicted, in graphic fashion, first, the number of operators actually at work each half-hour; secondly, the number of calls plus attempts made to complete ineffective calls each half-hour; thirdly, the number of calls without the additional attempts.

It will be observed how the traffic, insignificant at eight o'clock, rapidly rises between nine and ten, reaching its maximum at eleven. The influence of the luncheon interval—which in the City takes place between one and two—is very pronounced. The afternoon peak is usually a little earlier, but on this particular day it was delayed until five o'clock. The operator curve should follow the call curve very closely. In this case it does so, except in the afternoon, but the agreement, on the whole, is fairly satisfactory. The scales are arranged in the ratio of one operator to fifty calls per half-hour, so that at all times they are working well within the normal load. It must, however, be remembered that in this case all the calls are junction calls, and these are usually given the value of two, as two operators are in all cases concerned.



In the accompanying table is given a complete and most valuable set of statistics relating to the Central Exchange for the same day as that which has been shown graphically.

As the majority of the subscribers contract for the message rate—that is, they pay £5 per annum plus 1d. per call—it was originally anticipated that the number of calls per subscriber would be low, and that each operator would, therefore, be able to cope with 180 subscribers. No. 5 shows that the calls per line per day now reach the comparatively high figure of eight, and, therefore, No. 8—the number of lines per "A" position—is only a little above ninety-seven.

Comparing Nos. 14 and 20 shows that the proportion of "Central" traffic has increased, and is now 29 per cent.

Nos. 29 to 49 refer to the incoming traffic, and a comparison of No. 30 with No. 14 shows that there are five calls received by the Central Exchange subscribers to every four originated by them. This means that business flows, as one would expect, *into* rather than out *from* the City.

No. 36 confirms the statement previously made that the "B" operator can deal with over 250 calls per hour, this high average being due to the use of machine-ringing keys and the automatic character of the signals provided for her assistance. The joint influence of call-wire working and of a large number of junctions is shown by a comparison between Nos. 31 and 39, the traffic per

ANALYSIS OF PEG COUNT TAKEN MARCH 22, 1907

1	Number of direct lines	
2.	" stations	
	" originating calls (day)	
	" " " (busy hour) . .	
	Average number of originating calls per line ..	
	" " " station .	
	Number of "A" positions	
	Average number of lines per "A" position ..	97·2
	" " stations per "A" position ..	141·7
	" " calls " " (day)	784·5
	" " " " " (busy hour)	125·2
	Number of "A" position hours	
	mbe of calls per "A" position hour	
	itgoing junctic	
	'all- e junc	
	ringin	
	Percentage of outgoing junction calls	
	Ratio of business hour to day .	
	Number of local transfer calls (day)	
	" " " " (busy ho	
	" " " junctions	
	" " " positions..	
	Percentage of calls	
	" "	
	INCOMING TRAFFI	
	wire junc	
	. junc alls	
.	Aver. No. of calls per ming call	
.	Number of "B" positions ..	
	Average number of calls per "B" position .	
	" " junctions per "B" position	
	mber of "B" pos	
	erage n of cal pe siti	255·8
.	Nu inging ju	51
	" " " junction calls .	3,001
	r No. of calls per incoming inging junction	
	iber of "C" positions	
	rage number of junctions per "C" position	
		1,000
	of " n ho .	29
	alls per "C" position hour	34·4
.	Total number of incoming junctions . ..	1,043
.	" " " junction calls (day) ..	102,251
	" " " " " (busy hour)	15,108
.	Average number of calls per incoming junction..	98
.	Ratio of busy hour to day	·15
	JUNCTION TRANSFER	
.	Number of record operators..	1
.	" position operators	6
.	" calls received by record operator ..	977
.	Total number of calls handled (including additional attempts) by position operators ..	3,957
.	Average number of calls per position operator ..	659
.	Total number of calls dealt with	252,897
	" " " position hours	1,724
	Average No. of calls dealt with per position (hour)	146·7
.	Total number of employes	414
	" " " employe hours	3,466
	Average number of calls per employe (hour) ..	73·0

call wire junction being just treble the traffic per ringing junction. Nos. 40 to 44 refer to special positions connecting the third and fourth floors. The positions reserved for incoming ringing junctions are called "C positions."

Nos. 50 to 54 refer to special junction transfer positions, which have been introduced for the purpose of eliminating from the work of the ordinary operator all the difficult "outer London" calls. These take longer than usual to operate, and would unduly impede the work on the ordinary positions. Immediately such a call is received, the "A" operator transfers it to the junction transfer record operator, who writes out a ticket, and hands it to one of the six position operators referred to in No. 51. The difficulty of dealing with these calls is evidenced by the fact that No. 54 shows that these junction transfer operators handle 659 calls each, as compared with No. 10 for the ordinary "A" operator, the number in the latter case being 784.

Some Telephone Figures. Nos. 19 and 49 show that nearly 16 per cent. of this traffic has to be dealt with in the busy hour, and this is the basis on which the equipment of the positions has to be made.

No. 55 shows that in one day more than a quarter of a million calls were dealt with. If we take this as the average, and allow for 300 working days, it will be seen that in a year we have for *one exchange alone* the astounding total of seventy-five millions of communications, which is comparable with the telegraph traffic of the whole kingdom.

The figures given in Nos. 58 to 60 do not include the engineering staff, but the average number of calls per employe during the hour—namely, seventy-three—is very satisfactory.

As a final effort to convey some faint conception of the magnitude of this huge installation, we may inform the reader that the internal exchange work alone accounts for over 7,000 miles of wires, and that the total number of joints necessitated in its construction exceeded 4,500,000.

Since 1895 all the long-distance telephone lines connecting various "telephone areas" have been in the possession of, and worked by, the Post Office. In each large town there is a Post Office trunk exchange, and this is connected with the local exchanges, which usually belong to the National Telephone Company, by means of junction circuits.

Long Distance or Trunk Telephony. The methods of working are quite different from those employed in ordinary local services, and it is proposed here only to describe them briefly. In local exchange work the wires are numerous, and being usually short, are not very expensive, and the cost of the operating is one of the principal factors. All this is inverted in connection with the trunk system, where the cost of a single circuit may exceed £20,000, and the cost of operating it may be in comparison a minor factor. It is clear, therefore, that every effort must be made to keep such a valuable line fully employed, and, consequently, in a trunk exhange the number of lines per operator is very small—usually not exceeding five.

For the purposes of description it will be best to take a concrete case and describe the method of operating. A London to Birmingham transaction will serve as an example. Imagine, then, in each of these cities a trunk exchange connected by trunk lines. The lines are worked in groups, but we must at first confine our attention to one. It terminates in front of the operator in the shape of a jack and signal lamp. The operator is provided with pegs and cords, having supervisory lamps similarly arranged to those already described in connection with central energy working, and she also has access to junction wires and call-wire keys, which have already been referred to.

Making a Trunk Connection. Let us suppose that a London "Central" subscriber, No. 300, wishes to communicate with a Birmingham "Central" subscriber, No. 1,000. He first calls the Central Exchange, and when answered, merely says, "Trunks." The Central "A" operator connects him to a record circuit which terminates in the trunk exchange on a special "record transfer switch.' This lights a lamp in front of the record transfer operator. Behind her, ranged along each side of a long table, are operators with headgear instruments waiting to take particulars of trunk conversations required. A connection from each of these record operators terminates on a plug on the transfer operator's keyboard. Immediately the lamp lights, when No. 300 Central is connected, the transfer operator lifts an idle plug, and connects it to the record junction. This puts No. 300 London Central directly into communication with the record operator, who takes down his number and the number and town of the subscriber with whom he wishes to communicate. She then informs him that he will be called as soon as a trunk is at liberty, and he rings off. Down the centre of the table runs a long travelling leather band, and on this the record operator places the ticket. At the end of the table it falls into the hands of a distributor, and from her is received by a check girl, who carries it to the trunk section, where it is put in proper order, according to the code time shown on the ticket with other calls awaiting turn.

As soon as a trunk is at liberty, the London operator asks the Birmingham operator for "1,000 Birmingham Central." The Birmingham trunk operator speaks on the call wire to the Birmingham Central, and obtains connection by a junction with the Birmingham subscriber. Simultaneously, the London trunk operator speaks on a call wire to the London Central "B" operator, and obtains connection to the London Central subscriber 300.

Checking the Time. Having obtained connection to both the London and Birmingham subscribers, the London trunk operator finally makes the connection, and times the ticket by means of a calculagraph machine, which records on the ticket the time at which the transaction began. As a further check on the time, the London trunk operator presses a time-check button, and at the end of three minutes the lamp immediately above this button lights. The operator then enters the circuit, and asks whether a second three minutes is required. If so, she presses the time-check button again, and at the end of another three minutes notifies the subscriber, and terminates the transaction. The ticket is again inserted into the calculagraph, and a pressure on the handle records the time of completion of call and *also* the *elapsed* time.

Recently, however, a system of telegraph call-wire working has been introduced. A telegraph circuit is superimposed on one of the trunk circuits, and telegraph operators, in addition to the trunk switch operators, are provided at each town. Particulars of all calls are passed forward by this means in advance of the transactions, and, therefore, it is possible to reserve the trunk circuits themselves entirely for the conversations of subscribers. This method has been wonderfully successful in increasing the revenue from trunk circuits. An average of sixty minutes paid time is sometimes obtained.

Continued

SINGING PRACTICE

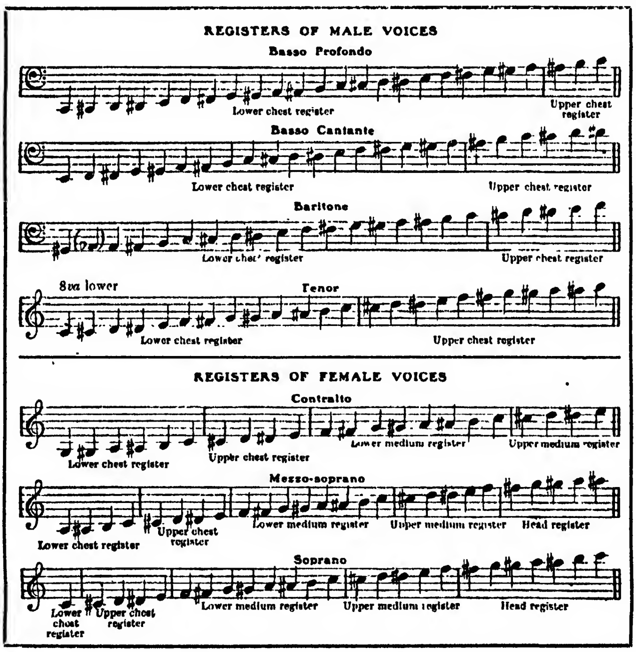
The Registers. Volume and Tone. Correct Attack. Faults to be Avoided. Exercises and How to Practise Them

By MARY WILSON

THE human voice is characterised by three distinct qualities of tone, called its registers. The word "register" has been described by Manuel Garcia as "a series of consecutive homogeneous sounds produced by one mechanism, differing essentially from another series of sounds equally homogeneous produced by another mechanism, whatever modifications of *timbre* and of strength they may offer. Each of the three registers has its own extent and sonority, which varies according to the sex of the individual, and the nature of the organ."

There are three registers, called respectively:

1. Open or chest, or *Voce di petto.*
2. Closed or medium, or *Voce di gola.*
3. Head, or *Voce di testa.*

In bygone days, before the study of physiology became general, it was firmly believed and taught that the chest or open notes were actually produced in and emanated from the chest; that the medium were actually produced in and emanated from the throat; and that the head notes were produced in and emanated from the head; and owing to this belief these names, chest, medium and head, first came into use. But the student must banish this absurd idea, all the notes being produced in, and emanating from, the larynx, or voice-box. Although by some authorities these names, chest, medium, and head, are not approved of, to avoid confusion it is advisable that the student should retain them.

The first to be considered is the open, or chest register, which subdivides into the lower and upper chest registers.

The Lower Chest Register. The deepest and strongest tones of the voice belong to the lower chest register. In singing these notes the feeling is as though they were produced in the lowest part of the lungs. If the hand is lightly placed upon the lowest part of the chest, the vibrations can be strongly felt.

When these notes are correctly sung the whole length, breadth and thickness of the vocal cords vibrate, and the windpipe and pharynx are very much expanded. As the voice ascends the scale, the great tendency of the larynx or voice-box is to rise; this must be carefully guarded against.

The Upper Chest and Medium Registers. All that has been said with regard to the lower chest register equally refers to the upper chest register, except that the vibrations are felt a little higher in the chest, and can be easily detected if the hand is placed upon the upper part. In singing the notes of this register, the whole of the vocal cords do not vibrate. In both registers the utmost care must be used that the notes are not forced. The mouth should feel full of sound. Men (basses and baritones particularly) have better chest notes than women. In female voices, the contralto has the best chest notes; light sopranos have scarcely any.

The medium or closed register like the chest register also includes two series of tone — the lower and upper medium. Some professors call the medium voice the *falsetto*, but since the word "falsetto" refers to notes "above the natural compass of the voice," the word here is a misnomer, for the voice of the medium register is as natural, if not more so, as that of either of the other registers.

The Lower Medium Register. The sensation felt when these notes are sung is as though the voice emanated from the throat. In singing the notes of this register the vocal cords come closer together; consequently the vibrations are quicker, the volume of tone is

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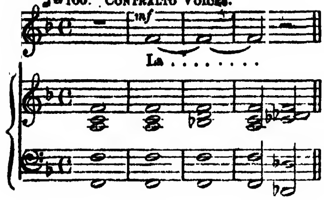
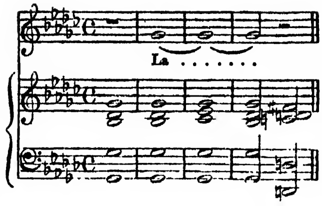
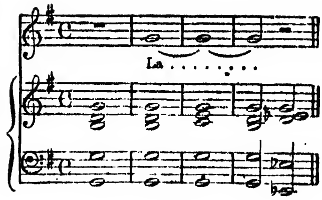
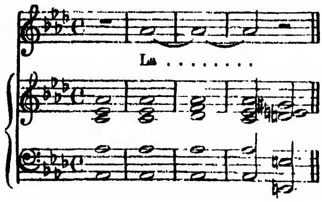
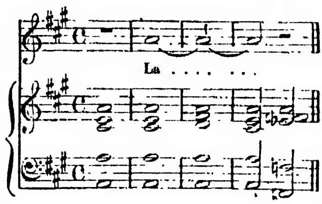
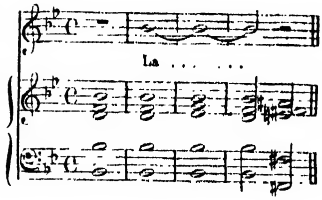
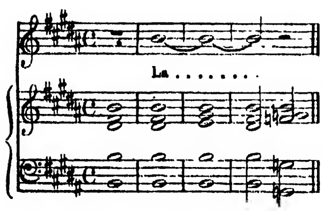
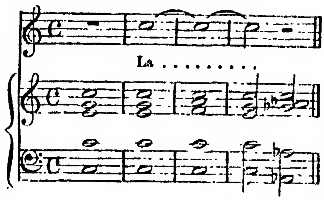
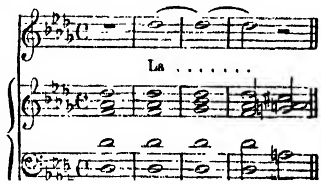
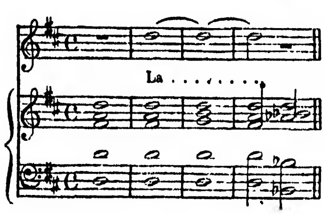
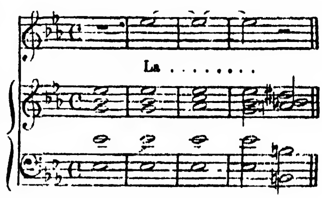





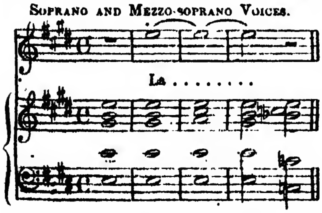
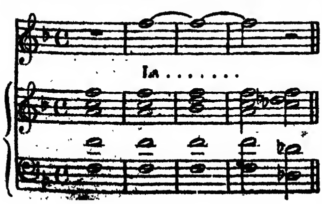
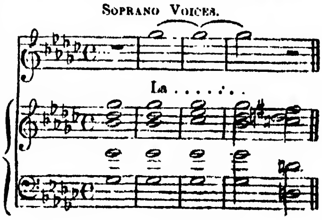
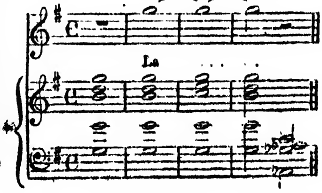
reduced, and scarcely any sensation is felt in the chest.

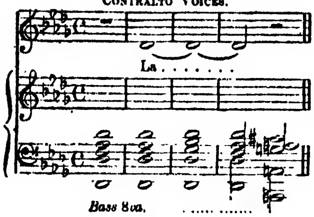
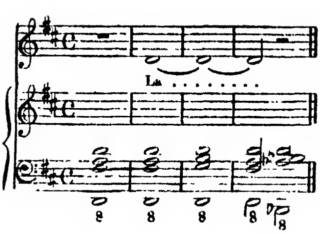
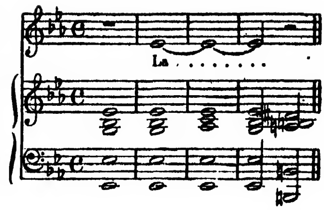
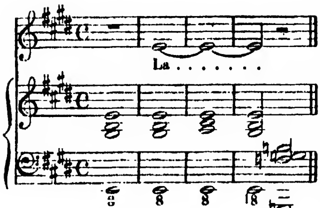
The pharynx is not so fully expanded; the soft palate and uvula rise, and close part of the nasal cavities, allowing the voice full scope to enter the mouth. Let the student remember that the breath must be directed on to the lips. On no account must the larynx be allowed to rise.

The Upper Medium Register. In producing the notes of the upper medium register the breath must be directed against the middle of the hard palate; the feeling then is as if the voice were produced in the upper part of the mouth, vibrating in the cheek bones. In singing the notes of this register also, the larynx must be kept low.

The Head Register. The sensation experienced when singing the notes of the head register is as though the sound emanated from the back of the head, vibrating in the posterior nasal cavities. The chink of the glottis is very small, the vocal apparatus contracted, and the vocal cords, being at their greatest tension, are very close together. As the student ascends the scale, the aperture or chink of the glottis becomes smaller and smaller until, finally, upon reaching the highest note, the opening is very minute. To produce these notes scarcely any breath is required, and the mouth must be kept wide open.

The soprano, mezzo-soprano, and tenor voices are the most noted for the head register. Occasionally one finds a contralto or baritone who possesses one or two head notes; but, generally speaking, when such is the case it is more than likely that the so-called head notes are nothing but the upper medium notes that have been trained as head notes. In this, as in the other registers, the larynx must be kept low.

Soprano and Mezzo-soprano Voices.

Soprano Voices.



Soprano, Mezzo-soprano, and Contralto Voices.

Timbre. Every human voice is divided into two classes—the singing and speaking voices; and each voice has, generally speaking, two timbres—the closed or sombre, and the open or clear. Quite irrespective of volume, each sound uttered by the voice possesses a number of shades, and these constitute its *timbre*. For example, take the vowels A E I O U, pronouncing them, Ah, Ay, Ee, O, Oo. Sing or recite each of these vowels on the same note, and with the same intensity of sound, listening carefully. The *tone* of each will be found to be quite different.

Beauty and Quality of Tone. It has been said that no two voices are alike. This being so, each voice must have some special characteristic; but, besides this, it must be either resonant or muffled, mellow or nasal, clear or throaty. The student should bear in mind that the qualities which constitute "beauty of tone" are resonance, purity, and clearness.

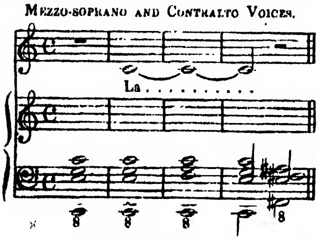
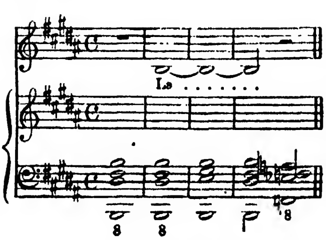
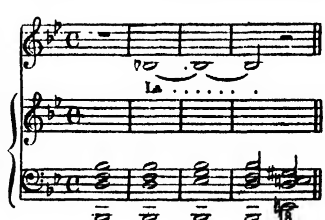
Although all tone is formed in the larynx, its quality depends almost entirely on the resonance chambers. If Nature has endowed the student with open, free, and good resonance chambers—chiefly the pharynx and nasal cavities—together with the free use of the soft palate, uvula, roof of the mouth, tongue, and teeth, it may be affirmed that the quality of the voice will be good—that is, presuming that the vocal cords are not defective. Numbers of people, some through force of habit, some through idleness, never use their resonance chambers to the utmost, and this causes the tone to sound faulty. In such cases this defect can be easily overcome by care and thought.

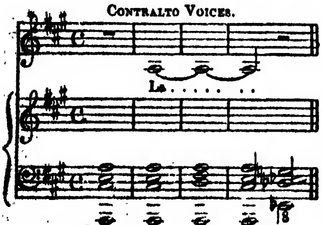
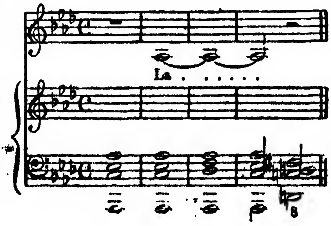
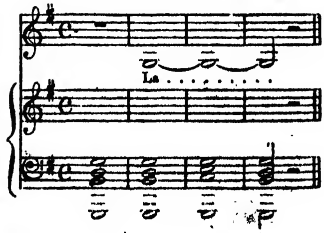
The voice should never be forced, and, after a correct method of respiration has been acquired, the student's undivided attention must be directed to the quality of tone.

Volume. Volume must not be confused with intensity. Volume is the size or magnitude of the voice, its loudness or softness; and to cultivate it the student must have some knowledge of, if he has not altogether mastered, the art of breathing. To acquire volume, the student must keep his larynx low, all the muscles of the throat free, the breath well under control—too much breath must not be expelled nor any undue pressure put on the vocal cords—the soft palate and uvula must be raised, the chest well expanded, and the tone directed to the front of the mouth, but there must be no forcing.

It should be noted that an intense tone is not necessarily a loud one. It is caused by the pressure of breath on the vocal cords. There are various degrees of intensity. These depend entirely upon the nature of the phrase to be sung or recited; the greater the passion to be portrayed the greater must be the pressure—but not force of breath—upon the vocal cords.

Attack. To attack a note properly is to begin it correctly, not scoop up or slur down to it, but to start it in the very centre. The breath must be well controlled; the attack must be

Mezzo-soprano and Contralto Voices.



Contralto Voices.

decided—not necessarily loud—quick and light. Signor Randegger compares it to "touch" in pianoforte playing, and he says "it corresponds to it in quickness, distinctness, lightness, and elasticity."

There is always a tendency in attacking the first note of a song or exercise to let the air rush out, leaving insufficient breath to finish the phrase. It is essential, therefore, that the whole of the vocal apparatus should be *prepared* and in readiness ere the order is mentally given for sound to be produced.

Unfortunately, "poor attack" is a very common fault with students of singing and untrained singers. This is chiefly owing to nervousness, which may cause the singer to attack the tone a little higher or lower than indicated; he will then slur down or scoop up to the correct tone; this is a general fault, but none the less bad. Sometimes a pupil through sheer fright dare not start to sing. Anyone at all afflicted in this way must exert all his will power to overcome his nervousness.

It not infrequently happens that "tightening the throat" to prevent the breath from escaping causes the attack to be incorrect. To repeat what has already been said over and over again, the diaphragm and rib muscles only—*not the throat muscles*—must regulate the breath control. Let the student remember that the attack must be distinct, decided and quick.

Faults to be Guarded Against. Some of the most general faults to be guarded against in singing are these:

1. Bad production—throaty and nasal singing.
2. Breath escape.
3. Tremolo and slurring.
4. Fatigue of the vocal apparatus.
5. Forcing the voice.
6. Tightening the throat muscles.
7. Faulty intonation.
8. High larynx.
9. Wrong position of tongue, soft palate, and uvula.
10. Facial contortions.
11. Movement of the shoulders.
12. Standing on the toes.

Bad production is due to two causes, the first of which is the root of the tongue pressing on the epiglottis, and so preventing a free passage of the breath. It is not an easy fault to overcome, so the student must exercise a good deal of will power and perseverance. Let him open his mouth naturally and fairly wide, and to see what he is doing he must practise before a mirror. Let the tongue be quite limp and lie naturally on the floor of the mouth, keeping the tip against the lower teeth. If he is not already able to keep his tongue "down," he must practise the exercises for the tongue given later.

The second cause of throaty or guttural singing is that the root of the tongue rises and forms a barrier at the back of the mouth. As the natural passage is thus blocked, the breath strikes against the barrier, and some forces its way round the sides of the tongue, some passes into the nasal cavities, and some is driven back into the throat.

When nasal singing is permitted, the tone sounds as though it were actually issuing from the nose. As a matter of fact, in certain cases some of the tone does escape through the nose. It is the result of not raising the soft palate and uvula, and the tongue at such times is often elevated at the root; in this way the breath is prevented from entering the mouth, and an undue amount is forced into the nasal cavities and nostrils. To remedy this, practise the exercises for soft palate and uvula given later on. In some cases nasal singing is due to adenoids. When such is the case, let the student see a doctor and have them removed.

Breath Escape. With beginners, breath escape is a very common fault. It is due almost entirely to a lack of proper breath management, together with a too slack tension of the vocal cords.

What actually takes place is that the breath, for want of control, rushes out through the vocal cords, which are not prepared to receive it. The result is that the greater part of the breath slips through, while only a small portion is used to make the cords vibrate; consequently the listener hears almost more breath than voice.

Let the student sing his exercises *very softly*, feeling all the time that the ribs are well expanded, and that every particle of air coming from the lungs is being used to make the note. This fault, which is really a grave one, since it prevents the voice from carrying, besides impoverishing it, must be corrected as soon as it is detected.

The horrible trembling of the voice, known as the tremolo, gives the listener the impression that the singer is trying to sing two notes and can pitch neither.

It is generally the result of over-straining, or it may be caused by training the chest register too high, forcing the head notes, a wrong method of respiration, ill-health, or nervousness.

If it is caused by over-straining, let the student practise *very softly*, not longer than a quarter of an hour at a time; if by training the chest register too high, be guided by the diagram referring to registers [page 6182], and practise all scales downwards, singing in the medium register as far as able. If by forcing the head notes, let the notes of the head register be sung *very softly* until all signs of the tremolo have disappeared.

If it is caused by a wrong method of respiration, give special attention to carry out all rules laid down for correct breath management; if through ill health, see a doctor at once; and if, lastly, through nervousness, concentrate on a thorough knowledge of exercises and songs. Slurring is dealt with later.

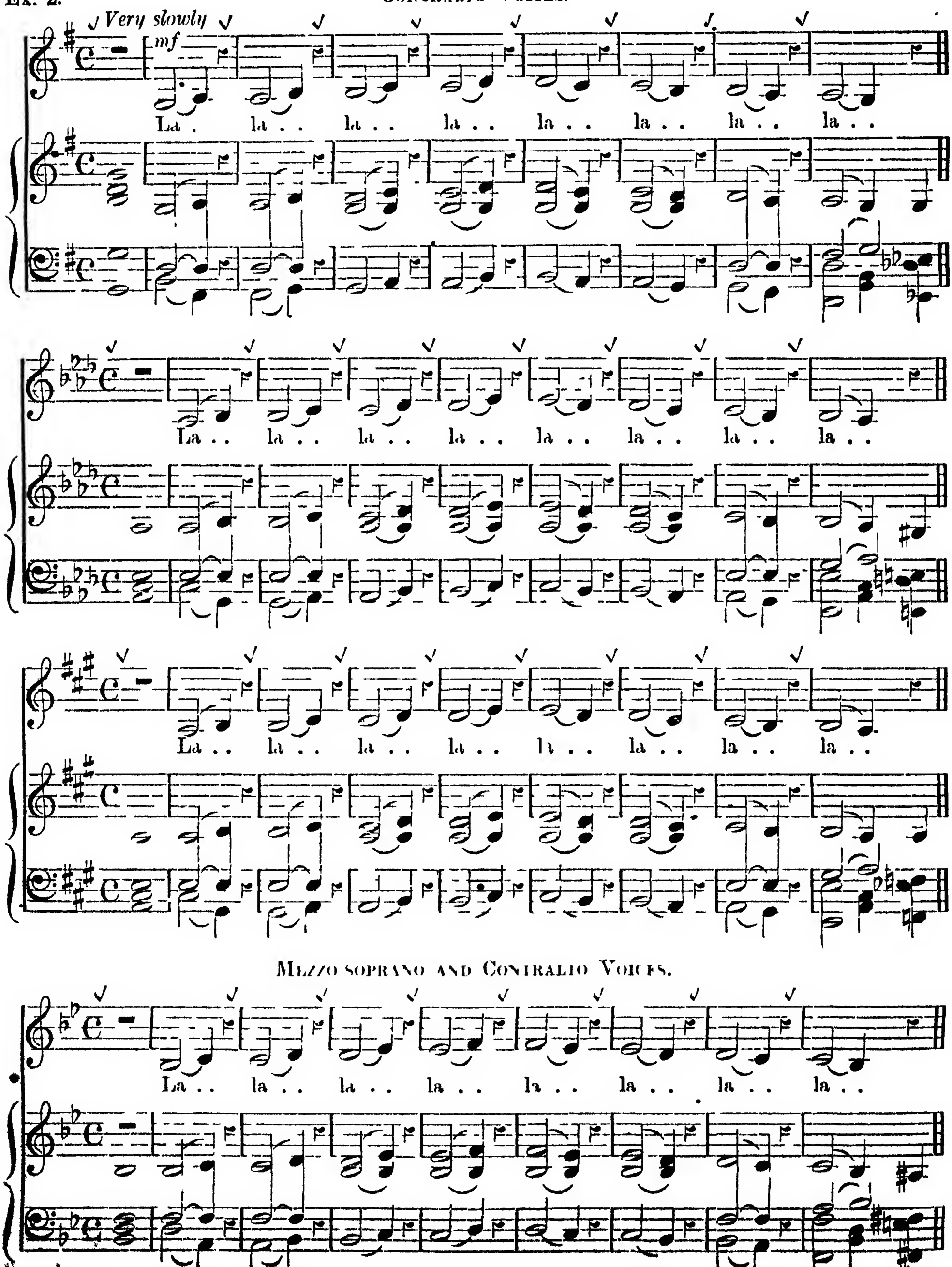
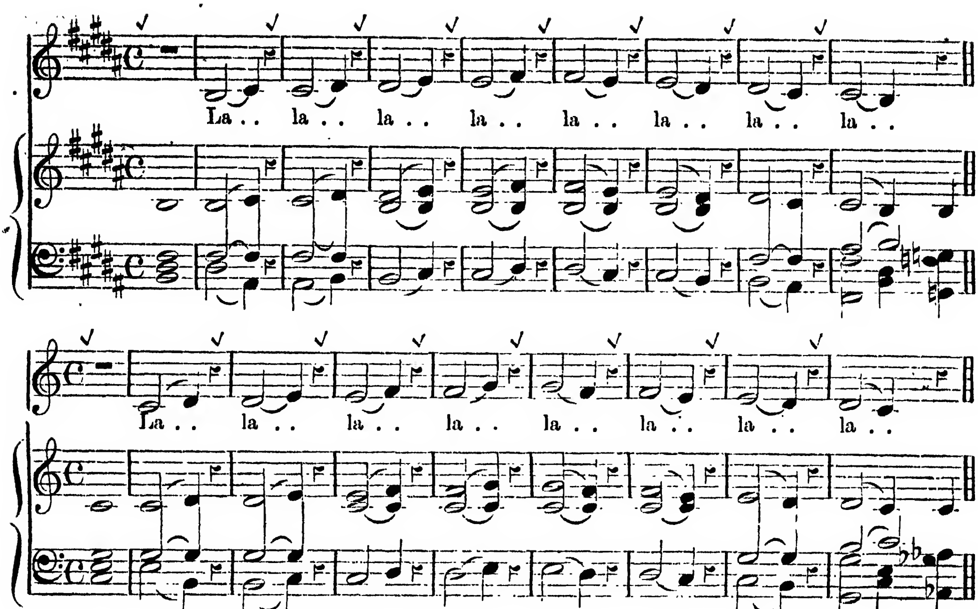
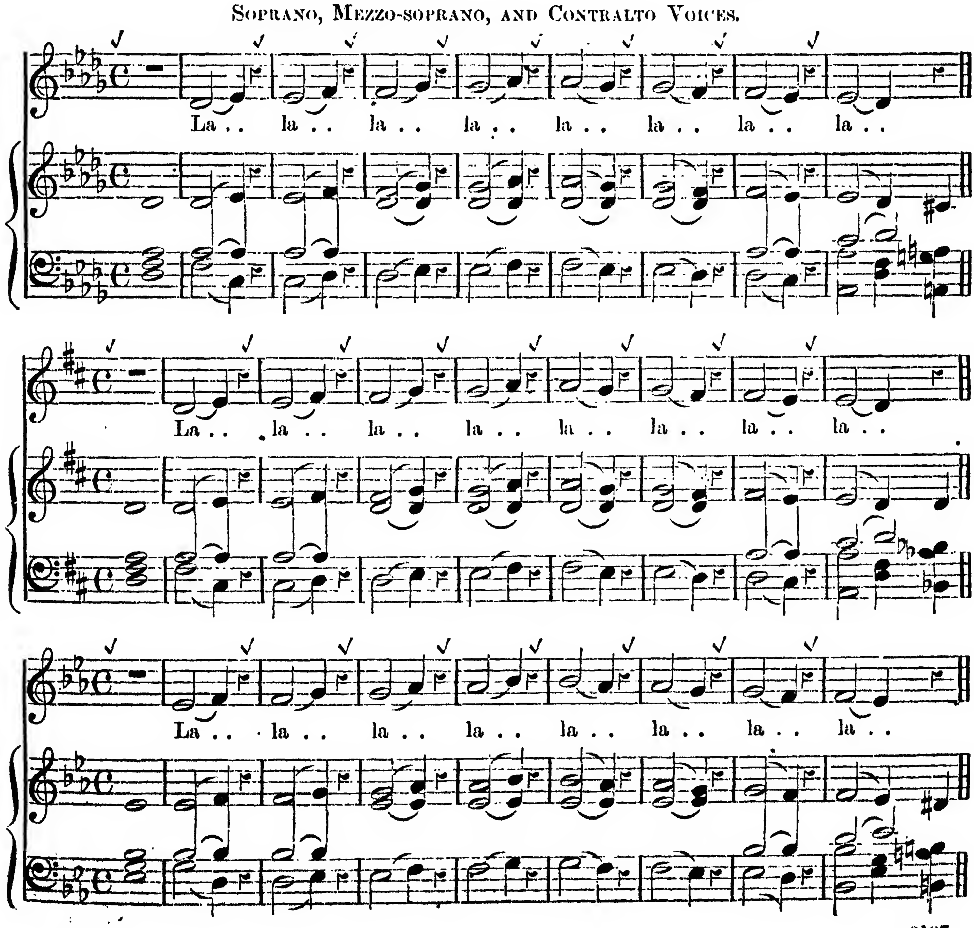
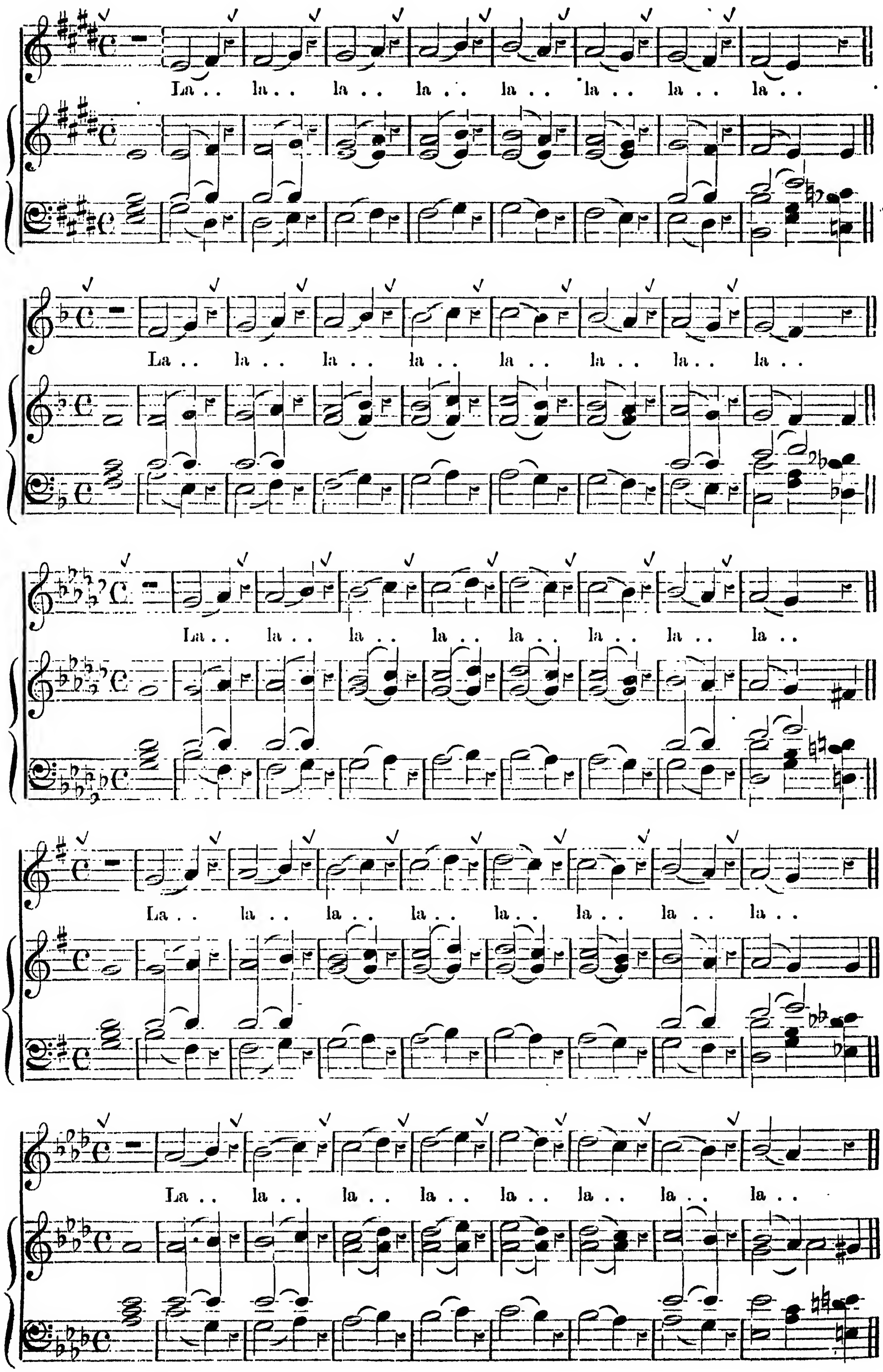
Fatigue of the Vocal Apparatus. Fatigue may be due to various causes, such as forcing, overwork, bad production, wrong method of study, general health, colds, tonsilar enlargement, elongated uvula, adenoids, and so on.

Much has already been said on the dangers of *forcing*. To overwork the voice in the hope of quickly developing it is one of the gravest faults into which a student can fall. A correct timetable for practice is given on page 6190.

The utmost importance is attached to a correct method of study, because when a wrong method is employed, it impedes the progress of voice cultivation very considerably.

The voice is most susceptible to every degree of health; it may be regarded as the barometer of bodily health. It will be observed, therefore, how very important is a high standard of general health. The student must never practise whilst suffering from a cold or sore throat.

Forcing the Voice. Frequently, the beginner in his eagerness to possess a big voice is apt to force it—that is, he is not content to let it develop slowly and naturally but must needs strain or drive it until he has gained size, but, alas! lost the quality. This fault

Ex. 2. CONTRALTO VOICES.

Soprano, Mezzo-soprano, and Contralto Voices.


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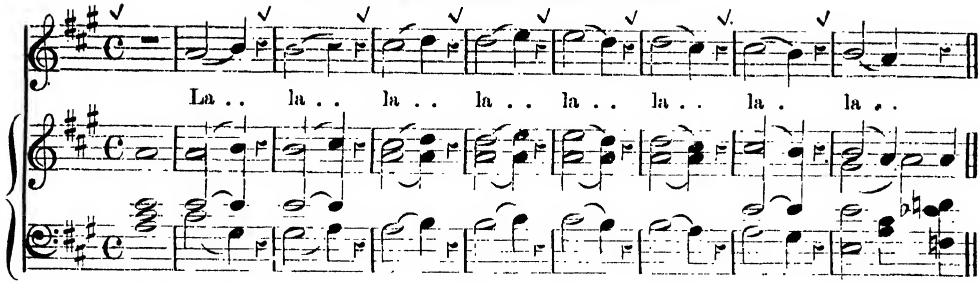
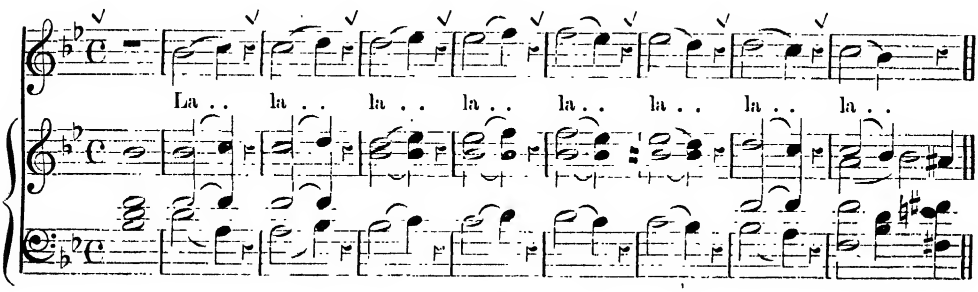
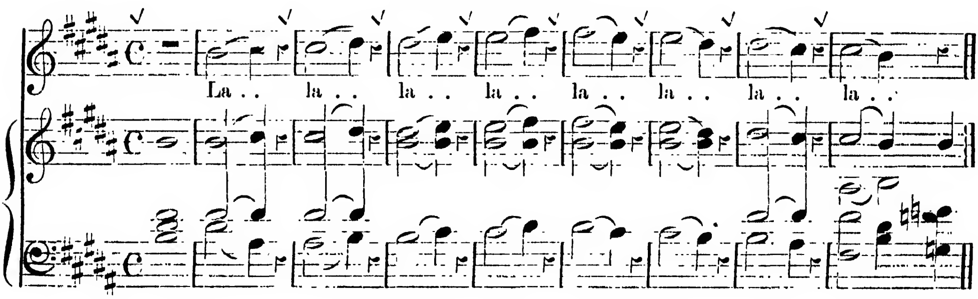
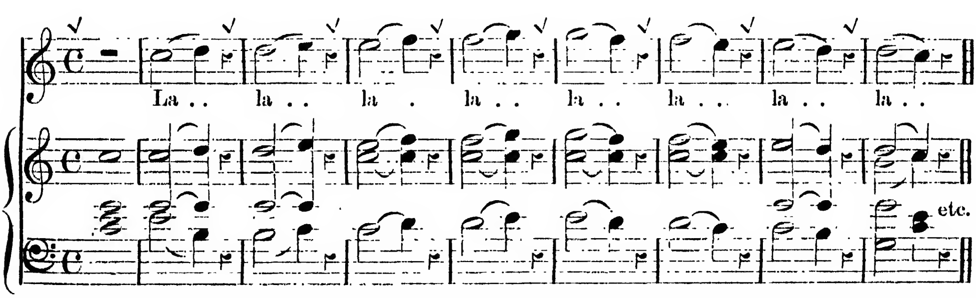
Soprano and Mezzo-soprano Voices.



Soprano Voices.





must be rigorously guarded against: if carried too far it spells ruin. Let the student who is thus inclined to force limit himself to singing *softly* until the fault is quite overcome.

The fault of tightening the throat muscles is most prevalent amongst sopranos and tenors. It is generally caused by a faulty method of respiration, and sometimes by singing with the larynx high. Let it be remembered that there must be no feeling of strain or contraction of the throat whatsoever; that a correct method of respiration must be acquired, and that the larynx, or Adam's Apple, be kept low.

Faulty Intonation. A person with faulty intonation is said to sing "out of tune," and to be either "sharp" or "flat." When "sharp" the note he means to sing is a shade higher in pitch than he intends it to be. This is caused either by tightening the throat muscles or by lack of musical ear. If the former is the case, apply the rules given for tightening the throat muscles.

If the "musical ear" is at fault, let the student strike a note on the pianoforte before attempting to sing, listen to it carefully, *mentally* aim at the pitch of the note, sing it, then strike the same note on the pianoforte again, and compare it with the note already sung.

This remedy also applies to lack of musical ear in "flat" singing. Flat singing may be attributed to ill-health, bodily and mental fatigue, lack of musical ear, but most frequently to carelessness.

High Larynx. It is utterly wrong for anyone to sing with a high larynx or voice-box. Because the larynx rises, it may be argued by some people that it is quite correct to sing with it high, but this idea must be abandoned. The larynx rises merely to let food pass more easily down the gullet, not in any way to assist in the production of tone.

Before uttering a sound, let the student open his mouth, lightly place his thumb and first finger on his larynx, or Adam's Apple, then swallow; the Adam's Apple will be found to move upwards and then downwards. When it is down it must be kept so, and in this position let the student sing a note. Let him continue practising this until able to put it into position unconsciously and naturally. When the larynx is *low*, the tone will be open, free and pure.

The Position of the Tongue. At the beginning of this course of study, the student will probably find it difficult to keep his tongue flat, and at the same time loose and free. Notwithstanding, he cannot be too assiduous in his endeavours to control it. If the student opens his mouth and tries to keep his tongue flat, he will find that in nine times out of ten it will immediately rise, either at the tip or the root.

To remedy this, let him take a hand-mirror; open his mouth rather widely, place and keep the tip of the tongue against the inside of the lower teeth, then try and draw the remainder of the tongue backwards, feeling as though the root of the tongue had disappeared. Practise without uttering a sound. Should the tongue still rise, let the student take a paper-knife and lay it along the tongue, trying to realise the sensations felt when the tongue is flat. Slowly, and without moving the tongue in the least degree, withdraw the paper-knife.

When he has repeated this exercise several times, let him again practise without the use of the paper-knife, and persevere until he is able to keep his tongue perfectly flat. On no account must he attempt to sing with the paper-knife in his mouth.

More often through carelessness and ignorance than any other cause are the soft palate and uvula allowed to "hang down" when singing, and thus impede a good production. If they are kept in this position, the tone sounds either nasal or as though it were produced through a thick curtain. The most beneficial exercise for keeping the soft palate and uvula "up" is to stand with the mouth well open, keep the tongue in position, and draw in a slow, deep breath through the mouth, directing the air towards the palate. The student will feel as though he wanted to yawn, and upon looking into his mouth he will observe that his soft palate and uvula have almost disappeared. Let him continue to practise in this way until he is able to raise them without obtaining the effect of yawning.

Mannerisms. Nothing makes a singer appear more ludicrous than facial contortions. Perhaps the most general of these contortions is the raising of one or both of the eyebrows. Other faults are undue raising of the upper lip at either corner, pushing forward the chin, inclining the head to one side, perpetual moistening of the lips, assuming a set smile, constant blinking of the eyelids, quivering of the lower lip, and a nervous twitching of the face generally. All these stupid faults can be overcome if the student will practise carefully before a mirror.

On no account must the shoulders be allowed to rise when singing; should they do so, it may be taken for granted that a wrong method of breathing is employed. As already pointed out, the shoulders should be kept down and well back, in an easy position. This is quite easy if the pupil acquires a proper method of breathing and practises before a mirror.

Another foolish mannerism, which may be easily overcome, is rising on the toes when a high note is sung. This fault is most general with tenors. If the student is inclined to raise himself on his toes, he will be wise to check it at once. Let him observe and carry out the rules for a correct position, then there will be no fear of his falling into this absurd habit.

Order and Length of Practice. The student will do well to follow out the following time-table for daily practice.

1. Long sustained notes on "La" or "Ma," slow exercises, half an hour.
2. Scales, arpeggios, and advanced exercises, half an hour.
3. Solfeggi, half an hour.
4. Songs, half an hour.

On no account must a single practice exceed half an hour.

The above table applies to advanced students only. Elementary students must never practise longer than one quarter of an hour at a single practice. If at first a fifteen minutes' practice is too long, practise ten minutes. The exact order and length of practice for elementary students will be given with each exercise.

The student should never continue practising until he feels fatigued. Sufficient time for rest should be allowed between each practice. An hour or more should elapse after a meal before attempting to sing.

Practising Hints. As regards the duration of each practice, hours of practice, and order of practice, it is of the *utmost importance* that the student should be consistent. He must have method in his work, and never be spasmodic. Unless he practises carefully, thoughtfully, and regularly, he might just as well never practise at all.

The student is well advised never to force his voice, or to shout; not to be too self-satisfied, and think he is perfect when he is only beginning;

never to practise to a pianoforte that is out of tune, and never to hurry over the production of his voice.

Let him *study with his brain* more than with his voice; it is useless to practise in "parrot fashion"; he must know and think why he is singing the various exercises; keep his jaw loose and free; avoid all mannerisms; keep to simple and regular diet; and, above all, work hard and diligently, and remember that "of learning there is no end."

Singing Exercises. Alike both in male and female voices, two elements are absolutely necessary for the production of voice—the breath and tension of the vocal cords. The size and depth of the voice greatly depend upon the size and development of the larynx. As already mentioned, men's larynges are much larger than women's; that is why their voices are deeper and less acute.

Now the art of respiration has been studied, and something learnt of the various registers, the student's attention may be directed to the first singing exercises. The female voices will be taken first and then the male ones, but the following remarks apply equally to both of the sexes.

(1) Stand in the position indicated in Respiration [page 6051].

(2) Let the jaw fall naturally.

(3) When the phrase allows, inhale slowly and fully.

(4) The sign √ marks the place where the breath has to be inhaled.

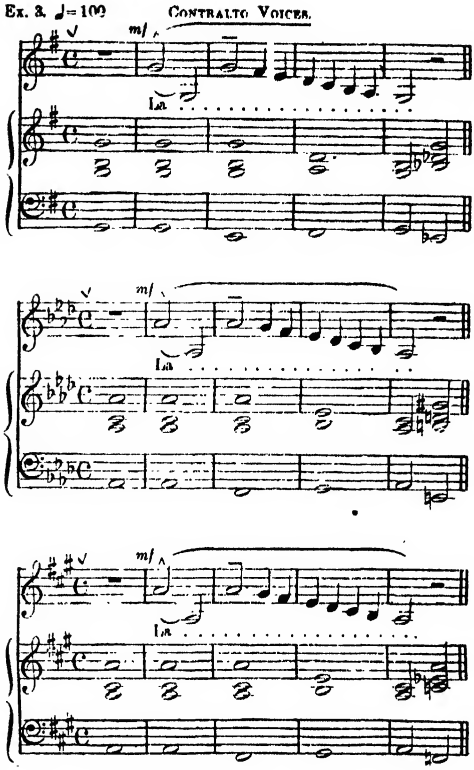
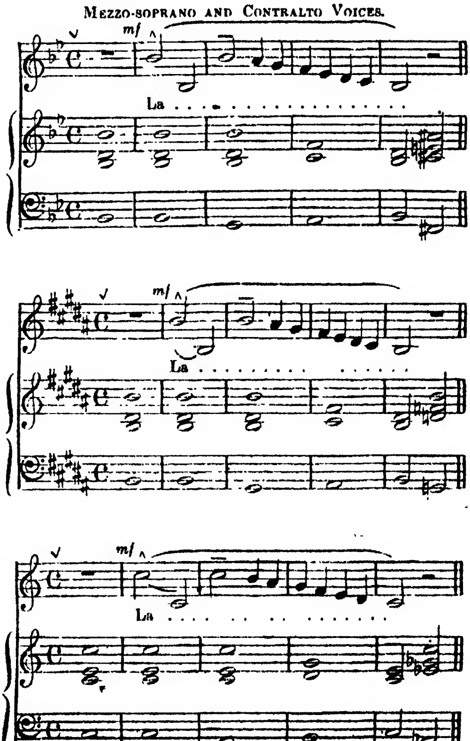
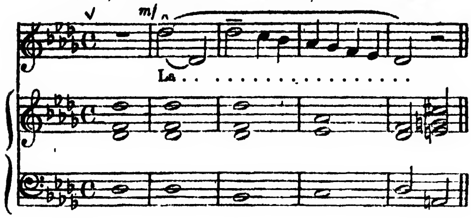
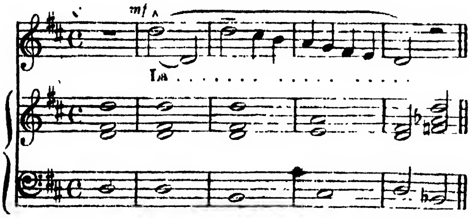
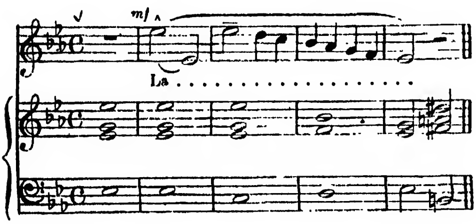
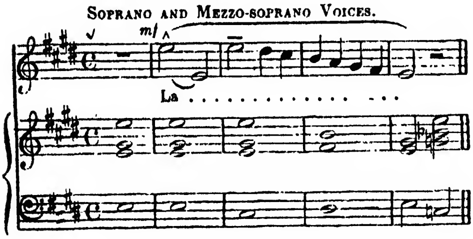
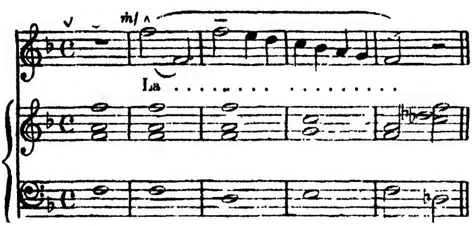
It is to be hoped that the student will, if he has not already done so, study the course on THE THEORY OF MUSIC beginning on page 37, so that he may be thoroughly conversant with the terms used in his singing exercises; for example, *mf* (*mezzo forte*) = moderately loud, *f* (*forte*) = loud, and so on. He is urged particularly to study TIME on pages 38–41. The student should try to realise that the more general musical knowledge he possesses the better will be the results he will obtain.

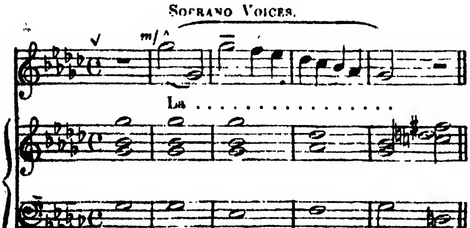
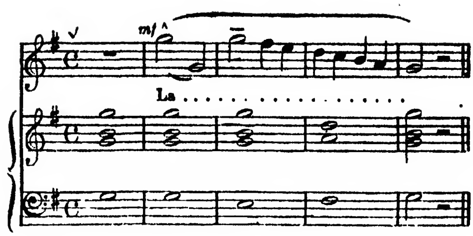
The cultivation of the female voice may begin when the student is in her eighteenth year. The male voice must not be cultivated until the student is nineteen years old.

In practising the exercises 1, 2, and 3 in this article the mouth must be sufficiently open to admit the *width* of the thumb between the upper and lower teeth. The tongue must lie flat and naturally, with the tip touching the inside gums of the lower front teeth.

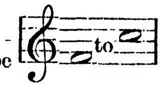
The consonants must be very distinctly articulated, and the exercises practised for several weeks—*mezzo forte*, then *forte* and *piano*—usually whilst standing before a mirror.

Breath must be inhaled as directed in the first exercise for inhalation, and during inhalation the note about to be sung—especially in Ex. 1—must be sounded on the pianoforte, and listened to carefully. The student must then *mentally* aim at the pitch of the note. This will help to ensure a correct intonation.

Ex. 3. ♩=100 CONTRALTO VOICES.

MEZZO-SOPRANO AND CONTRALTO VOICES.

Soprano, Mezzo-soprano, and Contralto Voices.

Soprano and Mezzo-soprano Voices.

Soprano Voices.

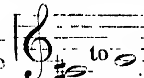


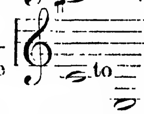
When singing the notes of

(*a*) the lower medium register inclusive the breath must be directed on to the lips ; 

(*b*) the upper medium register—inclusive—to the roof of the mouth ; 

(*c*) the head register—to the back of the head ;  and upwards

(*d*) the upper chest register—inclusive—to the front of the mouth ; 

(*e*) the lower chest register—inclusive—to the front of the mouth. 

A Practising Time-table. The following practising table should be adhered to if the best results are to be obtained.

First and second weeks, Exs. **1**, **2**, and **3** in this article.

Third week, Ex. 3, Randegger's "Singing Primer" [page 68]. Exs. **1**, **2**, and **3** in this article also to be practised.

Fourth week, Ex. 4, Randegger's "Singing Primer" [page 79], also exercises of previous weeks.

Fifth week, Ex. 5, Randegger's "Singing Primer" [page 83], also exercises of previous weeks.

Sixth week, Ex 6, Randegger's "Singing Primer" [page 86], also exercises of previous weeks.

Seventh week, Ex. 7, Randegger's "Singing Primer" [page 89], Exs. **1**, **2**, and **3** in this article, and Concone's "Solfeggi," Ex. 1.

All voices must be kept well within their natural compass in practising, and "La"—pronounced as in the word "father"—is the best syllable on which to practise. The first song may be taken about the ninth week.

Concone's solfeggi for the different voices are these: "Soprano, Mezzo-Soprano, and Tenor Voices: Fifty Lessons for the Medium Part of the Voice." "Contralto Voices: Forty Lessons for Contralto." "Baritone and Bass Voices: Forty Lessons for Bass or Baritone." Randegger's editions of the above are recommended, because the phrasing is excellent.

Before beginning to sing a new solfeggio, the student should study it, fully realising with what object the exercise was written, whether for "placing" the voice, the legato or staccato style of singing, sustaining, phrasing, portamento, *mezza voce, messi di voce*, blending of the registers, or attack. As before stated, "La" is the most satisfactory syllable to use for solfeggi, and it is

sung to the first note of each phrase, *not repeated with every note.*

A student may find he produces better tones on Ma, Na, Pa, or Da, in which case he must practise on the syllable most suitable.

When he is fairly familiar with the exercises, he must practise them on the different vowel sounds—ah, a, ee, o, oo, prefixing the different consonantal powers.

Basses and contraltos are advised to omit for several weeks the exercises that are to be sung quickly.

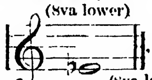
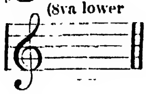
The Break. The student may find it difficult to pass smoothly, and without feeling a jerk, from one register to another. This " jerk " is most frequently noticed when passing from a lower to an upper register, especially from the chest to the medium. It is commonly called the " break."

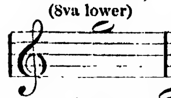
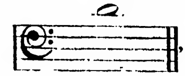
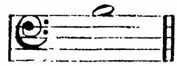
Perhaps of female voices the most troubled in this way are the contraltos. Many untrained ones have a very pronounced " break " somewhere between D (below first line, treble clef) and F (first space, treble clef). No rule can be laid down as to which note the voice must " break " upon—it depends entirely upon the nature of the voice—but on no account must the chest register in any female voice be taken above E (first line, treble clef).

It is often possible to carry the chest register higher than this note, but however easy it may be to the student to do so, it is a very injurious practice. Besides coarsening and hardening the voice, it makes the medium and head registers very weak, and is one of the chief causes of " tremolo." The same applies to the medium register ; it must never be carried up beyond F (fifth line, treble clef). Such a practice would make the " head notes " thin and shrill. The most beneficial exercises written for the " blending of registers " may be found in Randegger's " Singing Primer," pages 27–37.

Occasionally it is advisable when singing a descending scale passage to carry the lower medium register beyond its usual limit, and so not use the chest register. When sung in this way the passage is much smoother. On *no account* must the chest register in an ascending scale be taken above its limit. If this is done, the passage is coarse and broken.

As male voices use the chest register almost entirely, they are not affected by this " break."

The above exercises recommended for female voices may be used to advantage by the male voices, tenors beginning on (8va lower) , baritones on (8va lower) , basses on (8va lower) 

Male Voices. Male voices use the lower registers—chest and medium or " voce mista." The production of the " voce mista," or the " mixed voice," which, with tenors, begins at (8va lower) , baritones , basses  is very similar to the production of the upper medium register in female voices. When singing these notes " the cavity of the mouth must be completely filled with voice, which, energetically directed towards the arch of the palate, will rebound from it, rendering the sound full and sonorous " (Randegger).

The three exercises already given for female voices are recommended for male voices, and are to be practised in the same order, 1, 2, and 3 ; but instead of beginning on F (first space, treble clef), the tenor must begin with E flat (first line, treble clef), and practise to G (above treble clef) ; the baritone with B flat (immediately below middle C), and practise to E flat (fourth space, treble clef) ; the bass with G (fourth space, bass clef), and practise to C (third space, treble clef). It must be borne in mind that the notes actually sung by the male voices are an *octave lower* than those indicated by the treble clef.

As the voice develops the compass may be extended, either upwards or downwards, or in both directions, as is natural to the voice. The student is advised to limit his compass for several weeks. The directions given for female voices apply equally to male voices.

When singing the notes of the chest registers the throat must be kept well open, the larynx low, and the breath directed *on to the lips.* To produce the " mixed voice." correctly the mouth must be more open than for the chest voice, the tongue lie quite flat, and the breath directed *to the roof of the mouth.*

Signor Randegger says : " Every student of singing should pay particular attention to the various physical sensations experienced in producing the tones of the different registers."

The vibrations of the notes of the different registers are felt :

(*a*) Lower chest, in the lowest part of the chest.

(*b*) Upper chest, in the upper part of the chest.

(*c*) Lower medium, in the lower part of the mouth.

(*d*) Upper medium and " mixed voice," in the front part of the face and towards the forehead.

(*e*) Head, in the back part of the head.

Continued

Group 28
DYEING
5
Continued from page 5956

INSOLUBLE COLOURS

The Importance of Water in Dyeing. The Treatment of Water. Operations Preliminary to Dyeing

By HERBERT ROBSON

Insoluble Colours. The insoluble colours can be divided into two classes—those which are added to the dyebath in the usual way, but require a special solvent other than water to dissolve them, and those which are produced on the fibre. It might at first seem that the mordant dyes ought to fall into this second class, but, although the actual colour produced is undoubtedly affected to some extent by the nature of the particular mordant, yet in the case of the mordant colours a previously existing dye is employed, and the resulting shade depends mainly upon it, whereas in the case of the developed colours the dye is wholly manufactured in the bath, so to speak.

The first class is represented by the sulphur dyes, and the second, which may conveniently be styled that of the *developed colours*, may be divided into aniline black, paranitraniline red, and other diazotised colours.

Sulphur Colours. Canarine, discovered in 1821, might be ranked as the first of the sulphur colours, but it is an inorganic salt prepared by oxidising potassium sulphocyanide. The first of the organic sulphur colours (also called *sulphine* or *sulphide colours*) was Cachou de Laval, made in 1873 by fusing sodium sulphide with various organic bodies, such as bran and sawdust. It was followed *longo intervallo* by Vidal Black (1893).

The great fastness of the sulphur dyes is now bringing them rapidly to the front, although their use is at present confined to cotton dyeing. The dye is dissolved in sodium sulphide solution, and an average dye requires its own weight of sodium sulphide. Extra marks, however, require twice their weight, and the highly concentrated brands treble. Until quite recently these dyes have been put upon the market in a very impure state, so that enormous percentages of them were required; but this state of things is now much improved. This, perhaps, constitutes the most noticeable progress of the past three years (1904-6), and, together with the greater range of shade now offered, has brought this group into favour. Perhaps the average amount is now 10 per cent. of dye. Some of the very concentrated marks will give full shades with 5 per cent. or even 4 per cent. On the other hand, 50 per cent. of an impure sulphur dye may be necessary to produce the colour desired. These percentages are heavy, but the dyes are cheap.

The bath must be made with Glauber's salt and also carbonate of soda (soda ash) to increase the affinity between the dye and the cotton. Various special precautions have to be taken. Wood only must be used for the dye vat. The goods, although entered at the boil, should not be allowed to boil in the bath. Steam should be shut off as soon as the goods are in. During the dyeing, the goods must be kept immersed, as contact with the dye and with the oxygen of the air tenders the fibre, and at the same time tends to make it assume a bronze appearance.

As regards the quantity of sulphide of sodium to be used, the best rule is to put just enough to dissolve the dye. The colour will come out very thin if any notable excess of the sulphide is used. The bath is kept standing, and reinforced with dye and sulphide as may be required. The dyed goods are centrifuged, rinsed, and fixed with bichromate and sulphuric acid, with sulphate of copper or peroxide of hydrogen, or by steaming. Overaction of the fixing agent must be avoided, as it tends to weaken the material. In all cases the goods are rinsed free from fixing agent and then soaped to neutralise any excess of acid and also to take away the harsh feel left in the fibre by the dyeing. When the soap has been rinsed out nothing remains but to dry the goods.

Sulphur Dye Baths. A very essential precaution in dyeing with the sulphur dyes is to use baths as short as convenient. While the average cotton-dyeing bath has twenty times the weight of the goods, it should be restricted to about twelve times the weight in the case of the sulphur dyes. In some cases a simple air oxidation suffices to fix the colour so that the dye can be used like indigo. Such dyes are much preferred, and naturally so, as not only does the fixing in other ways cost time and money, but almost always alters the shade, thereby making it very difficult to dye to pattern. There are already more than 200 brands of sulphur dyes now upon the market, and the range is daily increasing. To begin with, black was the only colour producible with the sulphur dyes, but the makers have gradually added grey, brown, olive, blue, yellow, etc. At the time of writing a red has been put on the market (Thiogene Rubine O), which gives a darkish red, turning to a plum colour by after treatment with copper sulphate. Messrs. Bayer have also brought out a good violet (Katigen Violet B). The range of shade producible with sulphur colours is still comparatively limited, but it is growing constantly, and the sulphur colours are gaining in importance daily.

Since this course was begun the gamut of colour dyes has been almost completed. Quite lately a pure red has been added to the group. Thio Indigo Red B, sent out by Messrs. Kalle & Co., is a very remarkable dyestuff. It may be regarded as indigo in which the two imido groups are each replaced by an atom of sulphur. It therefore has the relationship with indigo on the one hand, and with sulphur colours on the other. Thus it may be reduced, like indigo, in the vat, or dissolved in sodium sulphide solution like a sulphur colour. The range of pink to red shades that it gives have notably assisted to complete the series of sulphur dyes. The dye combines well with indigo, with the other sulphur colours, and with basics, thus giving a range of shades with remarkable qualities of fastness.

Insoluble Azo Colours. In 1880, Read Holliday & Sons, of Huddersfield, patented a process of forming azo colours direct on the cotton fibre. The soluble azo colours are not cotton dyes, as no mordant has been found to fix them on this fibre, but Messrs. Holliday showed that they could be *made* on the fibre. The principle of the process of producing an azo dye is this. An amine, such as

naphthylamine, is taken, dissolved in hydrochloric acid, and then diazotised by treatment with sodium nitrite; the diazo compound so produced is then combined with a phenol or an amine, and a colour is produced; this may then be treated with sulphuric acid, and thus converted from an insoluble to a soluble form. Messrs. Holliday, in their process, cause the cotton fibre to be impregnated with a solution of the amine: the fibre is then passed through an acid bath of sodium nitrite, whereby the diazo compound of the amine is produced on the fibre, which is now passed into another bath containing an amine, or phenol, or some other body capable of combining with the diazotised amine to form a colour: what this will be depends upon the amine that has been used.

At the time little use was made of the discovery, and attention was urged to it once again when another English chemist created a sensation in the dyeing world.

Primuline, already mentioned as a direct cotton colour, dyes unmordanted cotton a primrose yellow. Mr. A. G. Green, now the principal of the Leeds Technical School, made the remarkable discovery in 1887 that by diazotising Primuline on the fibre with nitrous acid, followed by a treatment with a phenol or an amine, a range of very fast and beautiful colours was produced, varying with the developer used, for instance:

Beta-naphthol	gave	red
Beta - naphthol - disulphonic acid R ..	,,	maroon
Resorcinol	,,	orange
Phenol	,,	yellow
Meta-phenylene-diamine	,,	brown

As these were produced in the fibre, they were called "ingrain" colours, and the Germans call this class "ice colours," as a very low temperature is necessary for the diazotising bath.

Insoluble Azo Dyes. As regards the insoluble azo dyes, however, the number in use is very limited, but at least one, paranitraniline red, familiarly known as *para red* in the dyehouse, is highly important. It is produced by steeping the goods in a solution of sodium beta-naphtholate—that is, a solution of beta-naphthol in caustic soda, usually with the addition of Turkey red oil—drying and developing at once. The developing bath is made by dissolving paranitraniline in a hot solution of hydrochloric acid. Cold water is added, and when the bath is quite cold nitrite of soda is added. Naphthylamine Bordeaux is the next most important insoluble azo colour. It is prepared by diazotising alpha-naphthylamine. This has lately become more important in view of the vogue of "wine shades," and also because effective means of discharging it on the fibre, to produce white and coloured patterns, have been discovered. Dianisidine Blue is obtained by developing dianisidine with beta-naphthol.

Toluidine Orange, Amidoazo-toluol Garnet, and a few other insoluble azos have found limited uses and are produced in a similar way.

Aniline Blacks. Aniline black is generally divided into two classes—oxidation blacks and steam blacks. The formation of aniline blacks depends upon the oxidation of aniline. Its use is practically confined to cotton, because wool and silk, having reducing properties, seem to prevent the oxidation of the aniline. It is possible, however, that a previous treatment of the animal fibre with an oxidising agent, such as permanganate of potash or bleaching powder, will remove the difficulty, as the reducing powers of the fibre have vented themselves upon the oxidising agent, so that afterwards the aniline black can be applied by the same processes as for cotton.

Cotton is dyed in various ways with aniline black. When the oxidation is effected by a liquid, the black is called an "oxidation black." When, however, it is effected by air aided by steam, the black is a "steam black."

Oxidation Black. The following are some methods of preparing an oxidation black: (1) Make the bath with 40 per cent. hydrochloric acid (34° Tw.), 10 per cent. aniline, and from 10 per cent. to 14 per cent. bichromate of potash. The bath should weigh about 16 times as much as the cotton. The aniline is dissolved in the acid and the bichromate in water first. The aniline is then first added to the rest of the water and then the bichromate. The cotton is worked cold in the liquid for an hour. When the colour of the cotton is fairly strong, heat up the bath slowly to 140° F. to 150° F. At least three hours should be occupied in the dyeing as the slower the process is the less chance there is of the black turning green on exposure to the air. On lifting the cotton it is well rinsed, soaped, and rinsed again.

(2) The bath is made with from 16 per cent. to 20 per cent. hydrochloric acid, 20 per cent. sulphuric acid, 8 per cent. to 10 per cent. aniline, 14 per cent. to 20 per cent. bichromate of potash, and 10 per cent. of ferrous sulphate. If this bath is made considerably shorter than the previous one described it will produce the black without heat and with less tendency to weaken the fibre. The ferrous salt helps to prevent greening of the black. It is, of course, oxidised to ferric sulphate in the process.

Prevention of Greening. Cotton dyed aniline black by either of these processes is usually given an oxidising bath of bichromate and sulphuric acid as a precaution against greening, but the black is sometimes topped with methyl violet with the view of concealing any greening that may actually happen. Sodium chlorate is also used as an oxidising agent in the production of aniline black, especially on piece goods, but it requires the assistance of other agents. Lightwood used chloride of copper for the purpose, and ferrocyanide of potassium has also been employed. Probably the best yet known is ammonium vanadate or vanadium chloride.

The cotton is impregnated, for example, with 5 per cent. to 20 per cent. of hydrochloride of aniline, 2 per cent. to 10 per cent. of chlorate of potash, and a very small quantity of the vanadium salt (about three-thousandths of the weight of the aniline salt). The black is developed by oxidation in a current of air kept damp by steam and passing over the cotton at a temperature of about 80° F. A much better and quicker development is obtained by the use of the Mather & Platt, in which the goods are passed through hot steam in a closed chamber. The temperature used depends upon the kind of black in question, being about 200° F. for ferrocyanide black, but for Lauth's sulphide of copper black about 160° F. only.

Steam Black. The following is a good recipe for a steam black: Dissolve separately 6 per cent. aniline, 9 per cent. hydrochloric acid, and 12 per cent. sulphuric acid in 200 per cent. of water. Dissolve separately 12 per cent. of sodium bichromate in 200 per cent. of water, and mix the two solutions. Enter the cotton cold, and as soon as it is dyed, which takes two or three minutes, wring it and steam it for twenty minutes at 14 lb. pressure.

Artificial Indigo. The artificial synthesis of indigo is of decidedly earlier date than the putting of the product upon the market, but for a long time the cost of its manufacture prevented it from competing with the natural dye. In 1870, Baeyer & Emmerling made it from isatine, but isatine itself was not synthesised from coal-tar products until 1878. In 1880, Baeyer prepared indigo from cinnamic acid, and in 1882 Baeyer & Drewson prepared it from ortho-nitro-benzaldehyde by the joint action of acetone and caustic soda. This artificial indigo was put on the market in 1893, in combination with hydrosodic sulphide, under the name of indigo salt, by Kalle & Co. Another synthesis of indigo, from phenyl-glycocoll, by Heumann, was published in 1890. The process belongs to the Badische Anilin und Soda Fabrik, and forms the basis of the method by which that company now prepares its indigo rein (indigo pure), which was put upon the market in 1897. All these artificial indigos are identical with one another and with the indigotin of the natural dyestuff.

Operations Preliminary to Dyeing. Even if goods are to be dyed in the grey state they must pass through a preliminary treatment before they can be properly dyed. They have gathered grease and dirt in the processes of spinning and weaving, the wool has been purposely oiled, and the cotton warps have been stiffened with size, which will act as a resist to the dye. The goods, therefore, must be bleached or thoroughly scoured, or wetted out.

In these and in the dyeing processes the quality of the water used is of the first importance. A vast volume of it is required in the dyehouses, and an abundant supply of pure water is a prime necessity. Water must therefore be considered, to begin with.

Water. The question of "hard" and "soft" waters from the point of view of the steam user has been considered more exhaustively in another course. Here we must speak of water simply from the point of view of the dyer.

In bleaching or washing, the presence of the salts of lime and magnesia entail a waste of soap. In the neighbourhood of London a laundry with a supply of water marking 15° of hardness considers that it has "good water," and yet every 1,000 gal. of this water will destroy more than 20 lb. of soap before it gets to work on the clothes. The available water in some districts is capable of wasting twice or thrice this amount of soap without useful result.

In washing off after milling, a large quantity of water is used, and this, if hard, forms a soap curd in the fibre. This curd makes satisfactory dyeing impossible. Hard water can never be used for washing and scouring goods which have afterwards to be dyed.

Even a trace of iron in the water—and this is frequent—is disastrous throughout the operations of the bleacher and dyer. The student of this course has already seen that iron salts are used as mordants for dark shades. It does not require explanation, therefore, that iron in the water will dull bright shades. The lime, magnesia, and iron salts form insoluble soaps in combination with the wasted soap in scouring or bleaching. These are deposited in spots on the cloth, and will not only infallibly lead to uneven dyeing, but, in the case of the iron, will cause dark stains on the goods.

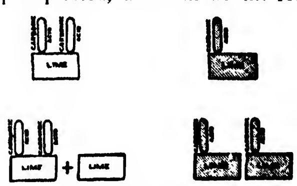
Apart from iron, the dulling effect of which is the same throughout all his operations, the bicarbonates of lime and magnesia, and in a less degree bicarbonate of soda, are most troublesome to the dyer.

The principal fault of water containing carbonate of soda is that it neutralises any acid used in mordanting or dyeing. The bicarbonates of lime and magnesia waste the mordants and dyes in a similar manner to the destructive process we have pointed out in the case of soap. They precipitate many mordants and dyestuffs, and reduce bichromates to neutral chromates, which give up much less chrome to the fibre, and are consequently less efficient as mordants.

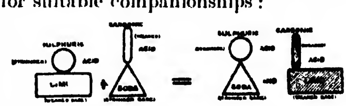
This will be sufficient to show that for the sake of economy and good results the dyer must purify the water he uses. Fortunately, the "permanent" hardness due to the presence of sulphates is of little consequence, although waters used for washing dyed goods should be fairly free from permanent hardness.

In the case of a fairly soft water, the dyer frequently is content to neutralise the carbonates present in the mordanting or dye bath with an acid. If sulphuric acid is added, for instance, the carbonic acid is driven off as a gas, and the carbonate is converted into a sulphate. A safer and simpler method, and absolutely necessary in the case of many water supplies, is to purify all water used for the boilers, and throughout all processes, by a preliminary treatment. This purification may be done by simply boiling the water, and thus converting the bicarbonates into carbonates by driving off part of the carbonic acid. On a large scale this is obviously impracticable.

Possibly, the simplest method and least expensive is to add lime-water (hydrate of lime) in a quantity calculated according to the degree of hardness of the water. This added lime is converted into carbonate at the expense of part of the carbonic acid in the bicarbonate, which consequently also becomes a carbonate, and the now insoluble lime salts are precipitated, and can be filtered off.



There remains, however, the permanent hardness to be considered, and for the sake of the boilers it is desirable to remove the sulphate of lime present. This can be done by adding carbonate of soda to the water in the form of soda ash. Then a double decomposition occurs, due to the familiar chemical law that the strongest base will combine with the strongest acid, Nature's great chemical example of her liking for suitable companionships:



The sulphate of soda does not form scale, and the carbonate of lime is precipitated as before.

It is evident that, apart from the question of initial cost, an efficient water softener must be simple to work, almost automatic, in fact, and that it must ensure certainty in adding the reagents in correct proportions; allow these proportions easily to be varied, according to the water to be treated; be able to run at varying speeds without adjustment; mix the reagents intimately with the water; allow complete removal of all suspended matter and thorough cleaning of the filtering material without removal. As an example, and as embodying these desiderata, the "Criton" Water Softener may be looked upon as an efficient apparatus, and this has been fully described on page 4096.

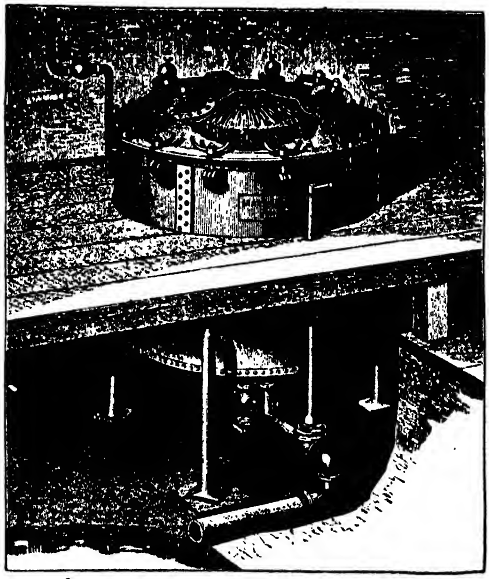
As the preliminary operations, and in particular bleaching, vary with the different fibres, we must consider them under the headings Cotton, Wool, and Silk.

Wetting Out Cotton. The grease and dirt is removed in this operation with a mild alkali, and the fibre is uniformly impregnated with water in order to allow the dye to penetrate it evenly. Air bubbles in the fibre are quite sufficient to cause uneven dyeing, and these are removed in wetting out. The usual method is to boil the goods with water containing 2 lb. or 3 lb. of soda ash per 100 lb. of goods. The addition of a pure, well-made soap assists the operation. In some cases the wetting out is done in the machine used in dyeing; for instance, raw cotton and sometimes hanks and warps are treated with boiling water for half an hour or more in the machine before the dyebath is made up, and piece-goods are given a few ends through boiling water on the jigger. More frequently a boiling-box or low-pressure kier [2] is used. Sometimes water alone is used—for instance, in cases where the dyestuff to be used would be affected by the soda—and in some cases it is advantageous to substitute a smaller proportion of caustic soda. This is quite sufficient preliminary treatment, as a rule, for dark shades.

Bleaching Cotton. The most perfect bleach is naturally needed by the calico printer, and in some cases, even for light shades, the dyer is content with steeping the goods already wetted out in a weak bath of bleaching powder, without heat, for a few hours, washing, souring with dilute hydrochloric acid and washing thoroughly.

The steps of the process are much the same in the case of yarn:

1. The yarn is steeped in water for a night to remove the grosser impurities, and to open the fibre to the action of the lye.
2. It is packed evenly into the low-pressure kier and boiled in lye. The circulating action of the kier is shown in the illustration. In this a rather long boil is necessary. The lye should be prepared with 3 per cent. of caustic soda. This frees the yarn from grease.
3. The alkali is thoroughly washed out in pure water.
4. The bleaching operation proper follows, and retains its old name—"chemicking." The apparatus used is very like a washing machine. It may consist of a wooden box, with a perforated bottom, placed over a cistern. The yarn is packed into the upper compartment, and the cold bleaching powder solution at about 2° Tw. is prepared in the lower. The liquor is pumped through a large rose over the goods and runs back into the cistern, and this constant circulation is kept up for six hours or so. This destroys all traces of colouring matter in the yarn.
5. The bleaching liquor is thoroughly washed out in pure water. All the washing operations can be very conveniently done in the chemicking machine described above.
6. A little hydrochloric acid is added to the water in the lower cistern, and the acidulated water is sprinkled over the goods as before for half an hour or less. This is called "souring," and neutralises all traces of "chemic" left in the goods.
7. The acid is thoroughly washed out of the goods. Plenty of water should be used, as traces of acid left in the yarn will tender the goods.

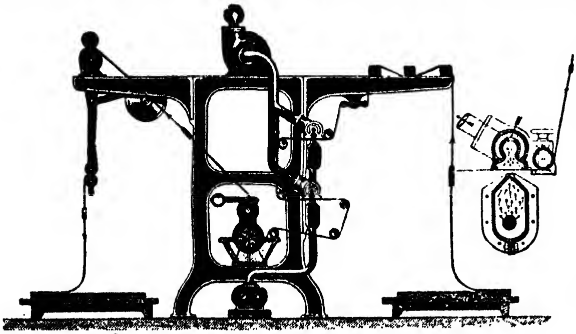


2. LOW-PRESSURE KIER (Mather & Platt)

Permanganate of potash, peroxide of sodium or of hydrogen, and other bleaching agents have been used for cotton, but their cost does not allow them to compete with chloride of lime

It must be remembered that this is merely the outline of the process. As a rule it is a separate industry, and the dyer receives his goods in the bleached state.

Singeing. This is a step of the bleaching process, especially when the cloth is to be printed, but frequently it is advisable to singe goods to be dyed in the grey, and it is a necessary process in lustre-mercerisation and Schreinerising. When yarn has to be singed, as, for instance, in the case of fine counts that are to be given the appearance of silk, either by mercerisation or by a mechanical process, this is a work of the spinner who "gasses" the yarn—that is, passes it at a high speed several times through the flame of a Bunsen burner. Many forms of machines are used for cloth, and the singeing is done by coal, coke or gas, and even electricity has been tried. Sometimes the cloth is passed over a hot plate heated by fuel, and at one time the difficulties in the way of employing the direct flame of the gas for cloth singeing made the plate machine,



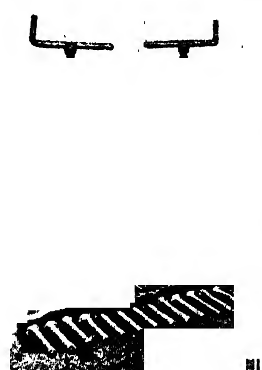
3. FELIX BINDER SINGEING MACHINE (Mather & Platt)

the principal one used for the purpose. It is still largely employed, but an inventor, Felix Binder, turned his attention to the gas singeing machine and made it efficient. As it is of more universal application than the plate machine, we describe and illustrate the Felix Binder machine [3], improved and manufactured by Messrs. Mather & Platt.

Binder found that the defect of gas singeing machines was that the hood and other parts became too hot. He remedied this by providing means for cooling the heated parts. The cloth to be singed passes over a wide slot in the underside of an exhaust chamber. The flame from the burner below is drawn gently through the cloth by means of a fan connected by pipes to the exhaust chamber. It will be noted in the diagram that this arrangement is duplicated, and that each side of the fabric comes under the action of the flame. The device is shown more clearly in the enlarged diagram at the side; the arrow to the right shows the direction of the cloth and that at the side the direction of the air sucked by the fan. The exhaust chamber is surrounded by a water-jacket through which a current of cold water flows, indicated by the arrow in the middle. The darts show the direction of the jets of flame. The burner consumes gas and air supplied by the Roots blower at the foot of the machine. The cloth passes over guide rollers through a damping trough, and is plaited down at the side of the machine. This is perhaps the most efficient singeing machine available; the consumption of gas varies from 16 to 200 cubic ft. per hour, and in this time the amount of cloth singed will vary from 12,000 yards to 18,000 yards.

Wool. Wool "in the grease"—that is to say, as it is obtained from the sheep's back—in addition to dirt, contains a heavy percentage of fatty bodies insoluble in water, known as "yolk," and a body soluble in water called "suint," consisting principally of potassium salts of organic acids. As these are removed before spinning, however, this is not the dyer's business. The woollen spinner, however, is obliged to oil the wool in spinning to give it suppleness, and whether from the yarn or cloth this must be completely removed before dyeing or bleaching. This is a simple enough operation if good olive oil has been used, but much trouble in the dye-house has resulted from the use of mineral oils, which are unsaponifiable.

Stretching. In the case of yarn it is usually necessary to "set" the fibre before dyeing, or otherwise it would shrink and become entangled. This is done by stretching the yarn in a frame between pairs of iron rods and boiling for half an hour or so. The upper pairs of rods can be raised by the action of screws, and the yarn very tightly stretched in the frame. In this state the whole frame is put into a boiling-box and after treatment for some time the hanks are pulled half round, the boiling is completed, and the hanks are taken from the rods and allowed to cool. The stretching machine shown in 4, made by Messrs. Elkanah Hoyle & Sons, of Halifax, has thirteen white metal spindles in each row. The hanks are put over the spindles and stretched tight by means of the strong screws. A hook at the end of a rope running through a block overhead is put into the eye-bolt and the whole frame is swung into a vat and boiled as described. This not only prevents the hanks from snarling, but puts a finish on the yarn.



4. YARN-STRETCHING MACHINE
(Elkanah Hoyle & Sons)

Scouring. The yarn is scoured in a solution of soap alone or of soda and soap, but the bath is not heated above 110° F. It is frequently done by hand, the hanks being hung on sticks as in dyeing, and moved forwards and backwards in the bath by two men standing on either side of a wooden tank, heated by steam. The position of the hanks on the sticks is changed from time to time, and when sufficiently scoured the yarn is washed thoroughly, squeezed and dried. A variety of machines have been devised for the operation, and in some of these the yarn is treated continuously, the hanks being made into a chain or placed loose on a travelling apron and carried through the scouring and washing baths between squeezing rollers. Cloth is not always scoured before dyeing when it is to be dyed black, but for the best work it is always necessary. A very ordinary form of machine is the "dolly." This practically consists of a pair of squeezing rollers revolving over a tank containing the bath of soap and soda. The pieces are sewn together in a continuous band and passed in rope form—that is to say, not opened out—through the bath by means of guide rollers and through the nip of the squeezing rollers. A trough immediately below these catches the dirty wash water, which is run off. In some cases the cloth would be creased in the dolly, and an open width machine is used instead. Practically the only difference is that the squeezing rollers are wider, and that a device is added to keep the cloth in tension and thus prevent it from creasing. In either case the scouring is continued until the pieces are perfectly clean, and they are washed in clear water and dried.

Crabbing. When the cloth is a mixture of different wools, and more especially when it is a union material—wool and cotton—the goods must still further be set by crabbing. This operation is described more particularly in this course in the chapter on mixture dyeing. The diagram shows a treble crabbing machine [5], made by Elkanah Hoyle & Sons, of Halifax. This is the standard machine used for Bradford textiles, and also for the light cloths of Huddersfield and Leeds. The first pair scours and extracts all the greasy matter from the goods. In the second pair warp and weft are "set" so that they will not cockle, and a lustre that cannot be removed is given to the goods. The third pair is the same process, but washed off in boiling water. Each pair of rollers is fitted with a cast-iron trough with a perforated boiling-pipe from end to end.

Bleaching. Wool is bleached in an entirely different manner to cotton, as the fibre would be totally destroyed in the lye boil. It is not usual to bleach it except for white cloth and for light shades. The scoured yarn or cloth is hung on poles in a brick chamber and "stoved," or "sulphured," as the operation is called. About 8 per cent. of sulphur is put in an iron pan in the middle of the room, and a red-hot iron is thrust into it. The room is then closed and the goods are left to the action of the gas—sulphur dioxide—for about

ten hours. Air is then allowed to blow through, and the goods are removed or washed.

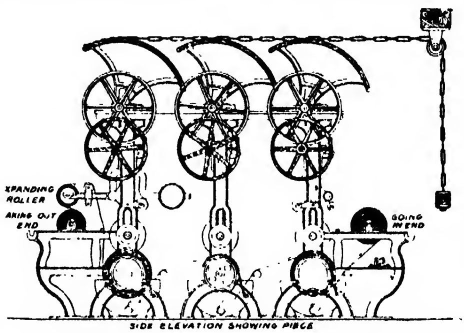
Sometimes a solution of sulphurous acid is used, or the goods are first steeped in sodium bisulphide and next in hydrochloric acid. In this case the sulphurous acid, being in a nascent state, acts very powerfully. Sulphur bleaching, however it is effected, is only temporary in its effects. The yellow tint of the natural wool will return, especially if the goods are washed once or twice. To counteract this, such things as white flannel are blued in the familiar manner of the laundry.

A much more permanent bleach is obtained with hydrogen peroxide, "oxygenated water," as the French call it, or with sodium peroxide. Hydrogen peroxide is very unstable, but it claims priority of use, and the process is very simple. It is, however, more expensive and less easy to keep than sodium peroxide; and this is generally used where the cost of the process is justified. It is highly important that no metal vessel should be used and that the water should be free from even a trace of iron. For 100 lb. to 150 lb. of wool the bath is made with 7¾ lb. of sodium peroxide, 3 lb. phosphate of ammonia and 8 lb. sulphuric acid in 100 gallons of water. All these ingredients must be free from iron. The sulphuric acid is first added to the water, then the phosphate and the peroxide are slowly stirred in. When the bath has been properly prepared it will have an alkaline reaction due to ammonia; it is now allowed to stand for about twenty minutes, and the scum that rises is removed by a wooden scoop or other suitable utensil. It is then ready to receive the scoured and properly rinsed goods. The wool is entered and the temperature raised to 110° to 120° F., and maintained at this for twenty-four hours, according to the thoroughness of the bleach required. The goods should be turned from time to time; and the bath may require the further addition of ammonia to maintain its alkaline condition, the necessity for which can be ascertained by the use of red litmus paper. When sufficiently bleached the wool should be lifted and allowed to drain into the bath—squeezed if practicable—and then thoroughly rinsed.

This gives a pure and brilliant white unattainable by any other means.

Silk. The object of the preliminary operations in this case is not only to prepare the material for dyeing but also to make it soft and lustrous. This is done by removing more or less of the silk glue, and according to the degree to which this operation is carried the material is called "boiled-off silk," "souple silk," or "écru."

Boiling-off. The silk is worked for an hour rather under the boil in a bath made with about 30 per cent. of soap. The gummy, soapy liquor that results is known as "boiled-off liquor" and is used in the silk dye-bath. The silk is then washed in water in which a little soda ash is dissolved, and scoured. For this process the silk is put into hempen "pockets" and boiled, sometimes as long as three hours, in a soap solution about half the strength of the previous bath. It is then washed thoroughly in soft water and dried.



5. TREBLE CRAB (Elkanah Hoyle & Sons)

Soupling. The raw silk is first scoured by working for about an hour in a lukewarm bath made with about 10 per cent. of soap and a little soda. It is then worked in a solution of aqua regia in a stone trough, bleached after the manner of wool by sulphuring, and, without removing the sulphur, is softened by working in a solution of cream of tartar at about the boil or a little under. The process requires experience and should be studied in special works, such as Hurst's "Silk Dyeing."

Écru Silk. This is simply scoured in a lukewarm bath of soap and soda. This removes the fats but very little of the gum. In this state it may be dyed black, but for other colours it is bleached.

Bleaching. Silk can be sulphured in the same manner as wool, but the white obtained is very fugitive. The best agent is peroxide of hydrogen. The scoured silk is simply treated in an alkaline bath of peroxide. It is entered cold, left for twelve hours, turned, left another twelve hours, and then the bath is made lukewarm and the process is finished in another three hours. This is slow, but an unhastened cold bath is better in peroxide bleaching, whether for wool, or silk.

The weighting of silk has been mentioned on page 5780. The boiled-off yarn is sometimes stretched between wooden rods, and gains as much as 3 per cent. in length without injury, while the lustre is increased. It may be steamed in the stretched state, which still further increases the lustre, or twisted up very tight and allowed to remain in this condition, which also has a glossing effect.

Continued

Group 15
HISTORY
43
Continued from page 5976

RUSSIA BECOMES A GREAT POWER

"Ivan the Terrible." The Days of Peter the Great. His Achievements at Home and Abroad. The Rule of Catherine II.

By JUSTIN McCARTHY

IVAN II., called The Great, who married the niece of Constantine Palæologus, took the title of "Ruler of All Russia." He marched against Novrogod and took possession of the city in 1481, killing numbers of its inhabitants. The retreat of the Tartars from Moscow in 1488 had the effect of freeing Russia from the Tartar-Mongol, but Russia's greatest enemy at that time was Lithuania, which was close to Moscow. The war with Lithuania and Poland began in the reign of Ivan III., and was continued by his son Vasili, who retook Smolensk.

The First Tsar. Ivan IV. succeeded Vasili in 1533 when he was only three years old. He was known as "Ivan the Terrible," and is one of the best-known of the Russian rulers. He reigned for fifty years, and was the first Russian sovereign crowned as Tsar. He did much during his reign to improve the arts and commerce of the country, as well as extending its territory, and he made a commercial treaty with Queen Elizabeth of England. Ivan the Terrible persecuted the Boyars, of whom he is said to have slain many thousands, and his cruelty was indeed so great towards the end of his life that he is generally believed to have become mad in his later years. He died in 1584—it is said from grief for having killed his own son in a fit of anger. His weak-minded son, Feodor, succeeded him, and he in his turn was succeeded by Boris Godenoff, who was chosen by the Duma.

The Beginning of Serfdom in Russia. Boris Godenoff was a man of great administrative ability, but his rule was not a fortunate one for Russia. He abolished the peasants' rights of free removal, thus instituting serfdom—the curse of Russia for many generations. To secure the succession for himself and his family, he exiled Feodor and his mother and caused the assassination of the young child Dimitri in 1591. Some years after this there appeared in Poland the famous impostor who called himself Demetri, the murdered son of Ivan IV., who succeeded in passing himself off as the rightful heir. He found many supporters, and was recognised as her son by the mother of Dimitri. He was crowned at Moscow in 1605, but the Russian people were soon disappointed in him, for he had married a Polish woman and was merely an instrument of the Poles. His imposture was soon discovered, and he was murdered in the following year in the palace where he had so lately been installed. Prince Vasili, who had risen against him, was proclaimed Tsar, but the Russians refused to acknowledge him, and Russia remained in a state of unrest until the Sobor elected Michael Romanoff, one of a family already popular in Russia.

Michael was the first sovereign of the House of Romanoff. He made peace with Gustavus Adolphus by ceding Schlüsselburg to the Swedish king. His reign saw insurrections of the peasants and wars with Poland. Under his son Alexis, Russia was further modelled into a state, and the administration was reformed, but there were, notwithstanding, many popular risings, and many troubles in the Church. The Patriarch Nikon endeavoured to attain the same supremacy in the East that the Pope had in the West, but the popular Church—the Old Faith, as it was called—opposed him, and he was eventually deposed and exiled. In this reign Poland was at last conquered by Russia, and the Russians also recovered Smolensk. Alexis was succeeded by Feodor in 1676, and on his death, six years later, his half-brother, Peter, was chosen Tsar.

Peter the Great. Peter the Great was the Russian sovereign to whom the country owes her sudden rise into power. He was born at Moscow on June 9th, 1672, four years before his father's death. When Feodor, his half-brother, knew that his death was near, he named Peter as his successor, excluding his own brother, Ivan, who was believed to be of weak mind. Ivan's sister, the Grand Duchess Sophia, opposed this nomination, and an insurrection of the militia, encouraged by her, rose against it. By Sophia's influence it was eventually arranged that Peter and Ivan should be crowned as joint rulers, Sophia acting as Regent during their minority. In 1689 Peter, who in the meantime had received an excellent education under the guidance of a Genevese named Lefort, called on his sister to resign the Regency, and, the military force of the country being on his side, Sophia had to give up the struggle. She was shut up in a convent, where she died. Peter gave his brother the nominal position of sovereign, but did all the work himself, and after Ivan's death, in 1696, he set to work to create a navy for Russia as well as a mercantile marine. The training of the navy was interfered with by the fact that Russia had only one port, and Peter, with the promptitude and disregard for principles of national equity which characterised him, declared war against Turkey and captured the port and sea of Asov.

How a King Went to School. Feeling that he had now made for himself and his country a settled position in Europe, he determined to study in the great capitals of Europe where civilisation was already established, the improvements which practical science had made in all departments of life; but he had first to suppress a revolt of the Strelzi, or militia, a peculiar military institution in Russia. He then visited the Baltic provinces, Prussia, Hanover,

and Amsterdam, where he worked as a common shipwright, and also studied astronomy, astrology, geography and natural philosophy. In 1697 he went to London, and at Deptford he again worked, entirely unknown, as a shipwright. While there he arranged for the emigration and settlement in Russia of a large number of surgeons, engineers, artillerymen, and artisans, for whom he was to find employment. When he returned to Russia he suppressed the Strelzi, which had given him so much trouble, and organised the new army according to the principles of the great European states.

Reform in Russia. A strong anti-reform party was springing up in Russia among the classes who, in every country, are opposed to all innovations. As his wife, Eudoxia, had associated herself with the anti-reform organisation, he obtained a divorce from her. Then he set about the work of reconstruction. He established naval and military schools, encouraged trade with foreign countries, remodelled the Press after the fashion of civilised Europe, and arranged for the publication in Russia of the best foreign books. In 1700, in alliance with Poland and Denmark, he engaged in a war with Sweden, then a powerful country. Charles XII. of Sweden, who had just succeeded to the throne, displayed his genius for war and compelled the Danes to sue for peace. In this success he was materially assisted by a squadron of English and Dutch under the command of Sir George Rooke, the famous English admiral.

Peter attacked Sweden, but Charles XII. defeated the Russians at Navva. Peter, however, continued his long contest with Sweden, and after some defeats he completely crushed Charles XII. and his army at Pultowa in 1709. Charles was not dismayed. He induced Turkey to declare war against Peter, and in this war Peter was reduced more than once to a condition which seemed desperate. He held out with his characteristic perseverence, and in 1711 he concluded a treaty by which he got out of the struggle with the sacrifice of the city of Asov and the land belonging to it.

Foundation of St. Petersburg. Peter had in 1703 laid the foundation of the new Russian capital, St. Petersburg, and in 1712 the seat of government was transferred to it. In the same year Peter married again. His second wife, Catherine, was the daughter of a peasant woman and a Swedish dragoon. After one of the Russian victories she became the mistress of Prince Menschikoff and then of Peter. In 1716–17 the Imperial pair made a prolonged tour throughout Europe, during which Peter obtained new ideas for the improvement of Russia. Some of Peter's reforms were again opposed by many of his nobles, and Peter punished his opponents with unrelenting cruelty. His son by his first wife, Alexei, was accused of joining the opposition to his father's plans, was tried, condemned to death, and actually died in prison. A treaty of peace was concluded with Sweden in 1721, by which the Baltic provinces and part of Finland were yielded to Russia.

A year after Peter forced a war on Persia, with the result that three of the Caspian provinces became part of Russia's dominions. The last years of Peter's reign were mainly occupied with projects worthy of his better days, for enlarging and adorning his new capital, and for the spread of education throughout his dominions. Suddenly he was attacked by a serious illness, and died, February 8th, 1725.

Russia under Menschikoff. On Peter's death, his wife, Catherine I., was acknowledged Empress of Russia. Catherine was wholly under the directions of Menschikoff, the Russian field-marshal, by whom she was first introduced to Peter, but who afterwards lost Peter's confidence because of his extortions of money for his own ends, and also because Peter suspected him of treacherous dealings with the enemies of the Emperor. Catherine restored him to favour, and during her reign and that of her successor, Peter II., he governed Russia with an absolute rule. He was already making arrangements for the marriage of his daughter to the young Tsar Peter, when an uprising against him by the old nobility proved too strong for him and his party, and he was banished to Siberia, after the confiscation of the vast estates which he had acquired by all manner of discreditable dealings. Death brought his career to a close on November 2nd, 1729. His great grandson became, in a certain sense, famous, for his was believed to be the main influence in forcing on the Crimean War, and he commanded the Russian forces at Alma and Inkerman, and in the defence of Sevastopol.

In 1727 the anti-reform party of the nobility set up the only son of Alexei, who had died in prison, as a claimant to the throne on the death of Catherine, and he became Emperor as Peter II. Peter II. was under the control of Menschikoff, and afterwards of Dolgorouki, and, like Catherine, was not in any sense the real ruler of the Empire.

Some reigns followed from 1730 to 1762 which were more remarkable for political intrigues and struggles at home than for great events in the world's history.

Catherine II. The reign of Catherine II. calls for more special notice. She was the daughter of a German Prince, and was born at Stettin on May 2nd, 1729. She was, by diplomatic arrangement, chosen when very young as a wife to the young Prince Peter, heir to the Russian throne. The young pair were married in 1745, and Peter III. became sovereign in 1762. Catherine had been brought up in comparative poverty, for many German princes had then very limited revenues. She was a charming woman, endowed with great political capacity, and was, indeed, one of the most capable women who ever occupied a throne. But she was unscrupulous and corrupt; she seemed to have no moral principles; she loved to be paid court to and surrounded by admirers; she enjoyed political intrigue, and personal intrigue still more. She and her husband never got on well, and in the earliest days of her married life her conduct was the cause of much scandal. After her husband

succeeded, in 1762, the quarrels became more frequent. Catherine was banished from the palace and constrained to live in a separate home. She had made many devoted friends and adherents by her commanding abilities, and by her attractions and her encouragement to her lovers. A conspiracy on her behalf was got up by several powerful nobles; Peter was dethroned and Catherine became Empress. Very soon after Peter was murdered, and there were many suspicions that Catherine knew of the plot to kill him.

Catherine and Potemkin. Catherine II. displayed great ability in carrying on the government, and the dominions and the power of Russia were greatly increased during her reign—increased with an utter disregard for all principles of international equity or for justice and morality. Catherine had moments of generosity and mercy, but she never shrank from cruelty where cruelty could serve her purpose. She had always some special favourite to whom for the time she entrusted the guidance of her affairs. The most notorious of these was Potemkin, a man of a noble Polish family, which, like many others, had been reduced to comparative poverty. He had a handsome person, and he entered the Russian army, where he distinguished himself, and soon attracted the attention and admiration of Catherine. She gave him the management, the government, in fact, of a large territory in the south of Russia, and De Ségur, in his "Mémoires," tells of an ingenious performance by which he secured the full confidence of the Empress.

An Elaborate Deception. Catherine announced that she was about to visit the region over which he ruled in order to see the prosperity it was attaining under his control. Potemkin, determined to make an immediate impression upon her, caused a great number of wooden houses to be constructed and arranged as separate towns and villages along the way the Empress had to traverse, and he hired a number of peasants and others to enact the part of contented and happy residents. This extraordinary piece of stage-play proved a complete success. Catherine was deceived by the imposture, and delighted with the evidence that the country was already rising in domestic prosperity, for which she hoped to have the principal credit. She conferred honours lavishly on Potemkin, and placed him at the head of the army. In the war with Turkey, in which the great victories of Bender and Ismail were won by Suwaroff, who served under him, Potemkin took all the credit, and made a triumphant entry into St. Petersburg in 1791. The favour Catherine showed to him made one of the many scandals of her reign. Potemkin was a clever man, ready and adroit, but unscrupulous and licentious. He made himself enormously rich, mainly at the public expense, and in spite of his extravagance he left an immense fortune when he died, in the October of 1791.

Success Abroad. The several partitions of Poland and its subjugation to the rule of Russia were reckoned by Catherine as among the triumphs of her reign. During her reign, also, there were wars with Turkey, which ended in another increase to the Empire, and there was a war with Sweden, which had for the time a like effect. The acquisition of the Crimea gave Russia the command of the Black Sea. Catherine professed the most advanced ideas and the fullest sympathy with the rights of the peasant class and the poor; but her rule was one peculiarly oppressive to those classes, for the power of the landlords over their serfs was greatly increased, and serfdom was restored in some territories where it had been abolished. She was a woman of great ability, and had literary gifts which might have won for her a more honourable renown than she acquired as an Empress. The impression made on students of Catherine's reign is that she was, all through it, playing the part of an Empress, according to her ideas, and thought only of captivating, on the Imperial stage, the vast audience who followed her movements with ever quickening wonder and admiration. Her memoirs are full of interest, and must hold the attention of every reader, but may shock many by their freedom of opinion and expression. Catherine died of apoplexy on November 17th, 1796. She had been much admired by many brilliant French writers and diplomatists, whom she did her best to attract to her Court and to keep around her. She was one of the ablest women who ever sat upon a throne, but it would be hard to decide whether Russia was the better or the worse for her life and her reign.

Catherine's Successor. Catherine was succeeded by her son Paul I. His reign though short, did much harm to the condition of the people. Paul's foreign policy was capricious; he restored to the condition of serfdom some of those who had before been made crown peasants; set up a severe censorship of the Press; prohibited the introduction of any published matter from foreign countries, and made the organisation of the secret police more effective than ever. There can be little doubt that the mind of Paul was unsound, and that many of his acts were to be ascribed to disordered intellect. He became so odious to many of those around him that a palace conspiracy was got up to compel him to abdicate, and when Paul resisted, a struggle took place, in which he was killed, on March 24th, 1801.

Paul was succeeded by his eldest son, Alexander I., the progress of whose reign brought him into prominent association with some of the greatest events in modern history. When he came to the throne all Europe was becoming disturbed by the French Revolution, and the history of Europe became for many years only the record of that Revolution's workings.

Continued

THE GENESIS OF A GARDEN

The Bare Land and its Preparation. Nature and Constituents of Soils. Laying Out the Useful Garden. The Importance of the Kitchen Garden

Group 1
GARDENING
1

Following BEE-KEEPING from page 5203

By HARRY H. HAVART

BETWEEN the wide expanse of pasture land which it is proposed to transform into a market garden, or beautify as an adjunct to a mansion, and the tiny plot of the suburban house, covered with builders' debris and overrun with weeds, there does not, at first sight, appear to be much connection. Yet, vast as the science of horticulture is, the same principles can be applied, with certain modifications, to the garden of the millionaire and to the tiny pot-plant struggling for life on the window-sill of a city slum.

It may appear superfluous to remark that anybody who desires to attain a knowledge of gardening must begin at the beginning, but there is a reason for saying so. Buying plants from a nursery in the springtime and putting them in the ground is not gardening, any more than paying a man to do all the hard work is, and, therefore, to acquire proficiency in horticulture, a novice must go right "back to the land" in its original condition.

The First Step in Gardening. The first step to be taken is to find out the nature of the soil one has to deal with. The chief constituents of all earth are one or more of the following substances in various proportions—clay, sand, gravel, lime, and decayed vegetable matter. Take a spade and turn over a few spits (a spit is a layer of earth the depth of a spade's blade) of the soil on the land or garden it is proposed to cultivate. Dig down to some little depth, as the character of the soil often varies somewhat two or three feet below the surface.

Now examine a spadeful of the earth. If it be thick and "stodgy" with clay, it is what is called a heavy soil, and will need a good deal of improving. If it contain a fair amount of sand mixed with clay, so that it is not sticky and sodden, it is a natural loam, the most precious of all soils to the gardener. Should there be so much sand, however, as to make it dusty and crumbly, it is known as a light soil, and wants careful handling. Where a large amount of chalk enters into the composition of the ground, as in many parts of Kent, and on the Surrey hills, the soil is called a calcareous one, and in its natural state is specially suited for the culture of many sorts of vegetables. The richest of all soils, though not the most useful for general purposes, is peat. This may be distinguished by its very dark colour, and the presence of decayed vegetable matter. It is met with most frequently in damp situations, and really represents the first stage in the transformation of vegetable matter into carbonaceous matter.

Draining and Levelling. When once the nature of the soil is known, it must be drained and levelled if the area is of considerable extent. Town and suburban gardens are, of course, already drained, and are generally of such limited area that they require no levelling. A simple and effectual way of draining is to dig a series of narrow trenches, six yards apart, from the highest points of the ground to the lowest, laying at the bottom of these trenches, which should be 3 ft. or 4 ft. deep, so as not to interfere with the roots of plants, a row of common earthenware pipes 3 in. in diameter. These must communicate with a larger, or main, drain pipe, which empties itself into a pond or stream, if one exists, or, if not, forms the nucleus of a pool, which, by this easy and natural process, becomes an admirable site for the water garden.

It is not necessary to give much attention to levelling a garden. The need for it is non-existent in the small suburban garden, and, as far as the market garden is concerned, levelling is a waste of money and time, except when sites for rows of glasshouses have to be prepared. For this purpose, however, and also for the formal part of the garden near the mansion, and in the preparation of tennis lawns, bowling greens, and other flat ground, some levelling must be done.

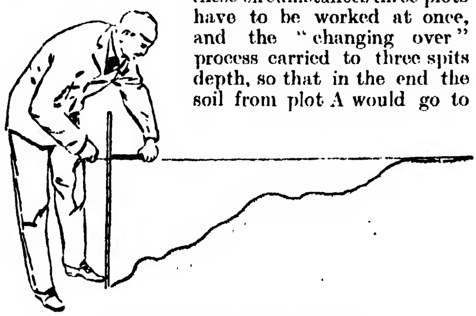
How to Level the Garden. This can be accomplished by very simple means. A peg, a length of cord, a stick marked with feet and inches, and a spirit-level are all the implements that are required. At what is judged to be the highest point of the ground to be levelled, a peg, with the cord attached to it, must be driven in. From thence the cord must be extended over the whole area until the lowest point is found. This is done by sliding the loose end of the cord up and down the measured stick at various points [1] until, by means of the spirit-level, the difference between the highest and lowest points of the ground is discovered. For the sake of illustration, suppose this to be 4 ft. Therefore it is necessary, in order to establish a common level, to throw 2 ft. of the soil from the highest part of the land on to the lowest part.

In practice more than this must be done, and the low parts to be filled should be built up to at least 6 in. higher than the spots from which the earth is taken to allow for subsidence, and also for compression when the roller is applied.

Digging and Trenching. The question of removal of soil brings us to the all-important subjects of digging and trenching. Digging is, of course, the simple act of turning over earth with a spade, but trenching is a term which the novice will need to have explained to him. Perhaps the definition given by J. C. Loudon, one of the greatest authorities upon gardening, is the simplest: "Trenching is a mode of pulverising and mixing the soil, or of pulverising and changing its surface, to a greater depth than can be done by the spade alone." This changing about of the soil in a garden is necessary for the purposes of aerating and sweetening it, as earth which is left too long undisturbed is apt to get foul and stagnant.

The simplest form of trenching is what is known as two-spit, or bastard trenching. Let us call two parts of the garden A and B. First the top spit and then the second spit of A are removed to a neutral spot, and the same is done with B, keeping the respective spits separate. Then the top spit of B is placed where the second

spit of A was, and the second spit of B put on top of it, while the top spit of A is placed at the bottom of plot B, and covered with the bottom spit A. In other words, the soil in the two plots A and B is taken up, turned upside-down, and made to change places [2]. For many gardens, especially suburban ones, where, as a rule, the soil is shallow and rests on a solid bed of clay, this form of trenching is sufficient, but where the soil is deep the operation of trenching is more complicated. In these circumstances three plots have to be worked at once, and the "changing over" process carried to three spits depth, so that in the end the soil from plot A would go to



1. LEVELLING THE GROUND

C, from B to A and from C to B, but inverted, so that what was once the top spit of A would be the bottom spit of C, and so on.

The Nature of the Soil. During the process of trenching, which may well be carried out while levelling is going on, much improvement can be effected upon bad soils. One remedy for a bad soil is to have the whole of it carted away to the depth of about 3 ft., and replaced with good rich loam from a nursery. This is, no doubt, a splendid method to adopt where expense is no object, but it is impossible in the ordinary market or private garden. These, as a rule, have too much clay in them.

The drawback to a heavy clay soil is that, being impermeable, it will not allow the rain to pass away, and, as a consequence, gets very sour. It is obvious, therefore, that anything which will tend to lighten or break up this heavy clay will be of advantage. This being the case, the autumn is the best time to commence the formation of a garden. The ground should be trenched as already described, and left as open as possible. Then, when the winter frosts come, the water which the clay contains will freeze, expand, and to some extent force the particles apart to admit air, and thus the soil will become somewhat more open and workable by the time the springtime arrives.

Manure. In these early stages the only manure, if any, which should be applied is a layer of horse manure, with plenty of straw. This should be placed at the bottom of the trenches—that is, after the earth has been dug out, and before it is replaced. Though this does little to lighten the soil, it increases its fertility to some extent.

Before beginning digging operations it will probably be found necessary to clear the ground of weeds and long grass. None of this refuse should be thrown away or wasted, but carefully stored and thoroughly burned, and the ashes dug into the ground. This process should be repeated at intervals with anything in the shape of rubbish that is capable of being burned. It is well, however, to change the situation of the bonfire each time, as even the heat and the action of the flames on the earth are beneficial to a heavy soil.

Road sweepings, with the grit they contain, to say nothing of the minute particles of horse manure, are of great value under similar circumstances, and although it is difficult to say whether it is legitimate to remove them from the side of the road before the scavengers come along, it is an easy matter to negotiate for a load or two.

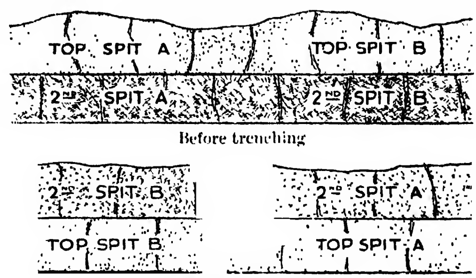
It is not sufficient merely to deposit the ashes, grit, and other lightening materials upon the ground. They must be dug over well and constantly until they and the soil are thoroughly well mixed up, as otherwise no beneficial results will be obtained.

Improving the Soil. By dint of patient and constant work it is thus quite possible to turn what was once regarded as a hopeless mass of clay into a fairly open, if somewhat heavy soil, while the presence of clay underneath at a depth of from 2 ft. to 3 ft., according to the distance trenched, is an advantage rather than otherwise, as it retains the moisture during the hot summer months, and so enables the roots of the plants to keep cool and prevents them being parched.

Improving a soil which is too light or sandy is not such an easy matter as improving a heavy one. The process may, of course, be reversed, and some clay introduced to thicken the ground, but the mixture rarely proves to be a satisfactory one. To make the best of a very light soil, it is necessary to trench it very deeply and openly before planting in the spring. This has two beneficial results. As the soil is thus rendered loose, the roots of plants can easily penetrate to a great depth in order to get at the moisture which is so necessary for their welfare; while, on the other hand, this treatment allows the rays of the sun to penetrate the ground freely, and so draw the moisture towards the surface.

When once the operation of trenching has been carried out, it is better to temporarily discard the spade for the garden fork in turning over the soil. Lumps of clay can be broken up more finely with a fork than with a spade, in addition to which the operation is not so fatiguing to the worker.

Foreign Elements in the Soil. In the course of these digging and forking operations, many large stones are sure to be met with. These should all be removed and set aside, as they have a use in the garden. If it is not proposed to form a pool for



2. TWO-SPIT TRENCHING

the culture of water-plants, these stones should be buried very deeply at the lowest point of the garden, where they will form a sort of rough drain and render great service in helping to carry away superfluous moisture from the garden.

Occasionally it happens in the course of digging that what appears to be a reddish-brown "vein" is struck. If this occurs, immediate action should be taken, as it indicates the presence of iron in the soil. Now, iron in a soil has a great tendency to render it

unproductive, so that prompt treatment is necessary, and a dressing of lime should be dug into the affected part. The iron is invariably in the soil in the form of an impure sulphate, and the lime combines with the sulphuric acid in the iron sulphate, and forms sulphate of calcium, thus sweetening the soil and eliminating the dangerous compounds.

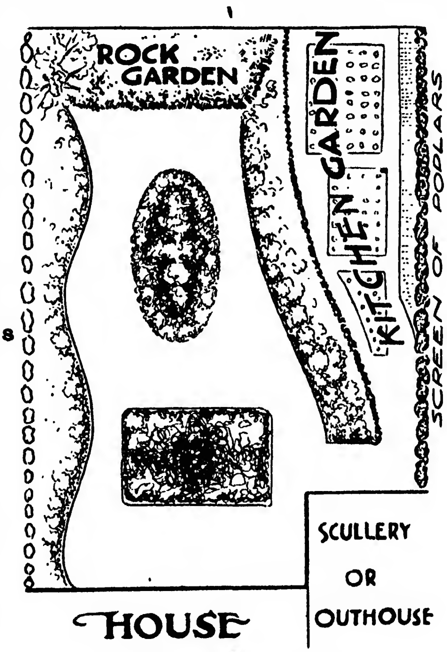
Magnesia, manganese, sulphur, phosphorus, soda, and chlorine are all found in varying proportions in soils of different natures. Where they do not occur naturally, and are required for the welfare of one plant or another, they must be supplied by artificial means, and this is the fundamental principle of chemical manuring, of which more will be said.

LAYING OUT THE GARDEN

Before beginning to lay out a garden it is obviously necessary to decide what sort of a garden is required. There is the garden for pleasure only, which is a flower garden pure and simple; the garden for profit—as distinguished from a market garden—the owner of which has merely an eye to the abolition of greengrocers' and fruiterers' bills; and the general purpose garden, which is a combination of the two, and is the garden usually met with, as well as the most useful.

The majority of very small town and suburban gardens are unsuited for the culture of fruit and vegetables, with the exception of a few kinds, and must, perforce, be gardens fo· pleasure only; but there is no spot, however barren and smoke-ridden it may be, which will not lend itself to gardening of some sort. The roof of the old Southwark Police Court, situated in one of the dirtiest and dingiest parts of London, was turned into a beautiful little garden by the gaoler attached to the place, who had as many as twenty or thirty different sorts of plants growing there at one time. How to deal with very small gardens, however, cannot be considered in this article.

The Aspect of the Garden. The very first thing that should be done with a piece of ground which has been levelled for gardening purposes is to determine its position with regard to the points of the compass. An ideal garden of moderate dimensions is oblong in shape, with the long sides facing north and south, while the house is at, and facing, the east end of the plot. In such a position the building protects the contents of the garden to a considerable extent from the cutting east winds, while there is a good expanse of south wall for the culture of fruit. Many a fruit-tree or half-hardy plant, which would die of exposure in any other situation, will thrive on a south wall, or in the border at its foot. Moreove-, a south wall gets the benefit of the sun for the whole of the day, in summer and winter, and is its own protection from north win?s. The terms south, north, and so on, when applied to walls in gardens, do not mean that they are situated in that particular part of the ground, but that they have a southern or northern aspect, as the case may be.



3. PLAN OF A SMALL GARDEN
Showing kitchen garden and screen of poplars

The novice visiting a garden of any pretensions for the first time frequently wonders why it is situated at one side of the house instead of at the back. It is just this question of exposure to sun and winds from different quarters that has provided the reason, and the same rule holds as good for the 12-ft. patch as for the nobleman's broad acres. The worst position of all for a garden is one in which the house faces west or south-west, as the garden has practically no shelter from the icy blasts from east and north. In laying out such a garden, therefore, plants of the most hardy nature must be chosen.

One of the first questions which will enter the would-be gardener's mind, as he stands at a back window and contemplates the waste which he is to make fertile, is: "How much of this ought I to devote to fruit and vegetables, and how much to flowers?"

A great deal depends upon local conditions. If the district is one well furnished with markets in which fruit and vegetables are procurable at reasonable rates, it is better to devote the bulk of the space to floriculture, reserving a little for the choicer products of the kitchen garden. If, on the other hand, vegetable produce is dear, and, as is often the case in country districts, consists chiefly of inferior local varieties, it is wise to make the kitchen garden at least half of the total area. This remark applies to gardens from which it is hoped to derive both pleasure and profit.

The Kitchen Garden. Having decided what proportion of the ground to be laid out is to be devoted to kitchen garden purposes, the next step is to mark it off nd divide it from the flower garden. Useful though they are, vegetables grown, as they should be, in symmetrical rows, like regiments of soldiers, are not a particularly alluring prospect in a garden landscape, and it is usual to separate this portion of the garden from the pleasaunce by a hedge of some description—a subject to be dealt with later.

In the smaller gardens it is usual to find the kitchen garden consisting of a corner lopped off indiscriminately from whatever part of the ground happens to be situated at the farthest point from the house, irrespective of situation or aspect. This is a mistake. The question of aspect is just as important for the successful culture of fruit and vegetables as of flowers, and, speaking as a general rule, with the orthodox oblong garden the vegetable portion will best repay attention if it is formed of a strip running parallel with the flower garden for practically the whole length of the ground. It may

be stopped within a few yards of the house or eased off into nothingness, so as to give the broadest expanse of bed or lawn near the house [3].

If a very large garden is in course of preparation the kitchen garden is, of course, a thing apart, and is kept away from the flower garden altogether. In these cases a position on a southern or western slope is usually assigned to it if such be available, but the laying out of places of such dimensions is not usually entrusted to an ordinary head gardener. A specialist, known as a landscape gardener, is invariably called into requisition, and the resident gardener and staff work upon the lines which he lays down.

Improving the Aspect. Though the question of aspect is one of the utmost importance, a good deal may be done to improve a bad situation. Where a garden is swept by east or north winds, a screen of trees, such as poplars, will assist matters materially. Certainly, unless large-sized trees are obtained in the first place—and this is a somewhat costly business—they take some time before the benefit of their presence is felt; but when once established, the advantage they offer is permanent. It should always be borne in mind, however, that on no account should a screen of trees be placed close to a house. In the first place, if the house has any pretensions at all to architectural beauty, the presence of trees, or tall-growing shrubs, in its immediate vicinity will sadly mar its dignity, while, in addition, big trees close to the house should be strongly discountenanced from a hygienic point of view. A house hemmed in by big trees is always damp, and they offer obstruction to light and air.

The Garden Walks. The question of walks and paths and where to put them is one of paramount importance in laying out a garden. At least 90 per cent. of gardens of all kinds in this country are wretchedly undersized little places, and yet the tendency is to reduce the available space in them by the introduction of needless walks, leading nowhere in particular, and serving no good purpose. It is a good plan when beginning operations to draw a rough sketch of the ground, marking upon it the different spots at which the kitchen, rock, water, and other gardens, if any, are to find a place.

Then, starting from the house, decide the simplest and quickest routes by which the different parts can be reached. Here a certain amount of discrimination is necessary. There is no need for the paths to radiate with geometrical accuracy like the spokes of a wheel from the back of the house. A graceful curve, which perhaps the presence of a tree or a rise in the ground will give a pretext for, is not only desirable, but to a small garden will give the impression of increased size. At the same time it is absurd to have a lot of serpentine walks wriggling about the place just for the purpose of conveying the idea of great length, while bisecting and trisecting lawns with walks until they look like a problem in geometry is an equally foolish proceeding.

Grass Walks. Unless a garden is of unusual dimensions, three or four main gravel walks, at the most, will be all that will be required, and, for the rest, let the turf come right up to the beds or borders, so that what would under ordinary circumstances be gravel paths are simply grass walks. There are many advantages to this system. The rich green turf forms a far more beautiful setting for a bed of flowers than a gravel path does. It is easier to keep turf in good order than it is to be continually weeding gravel, and although it is urged as a drawback that turf walks are unfit for walking upon after rain has fallen, this is only the case where they have been improperly drained. Moreover, should it be desired at any time to change the character of a garden, this can be far more easily done in a turfed place than in one where gravel walks, running at different angles, have to be taken up and altered.

Making Beds and Borders. Mention has been made of the words "bed" and "border." A bed is a piece of ground in the garden, prepared for cultivation, but which has no direct protection from a wall, fence, or hedge. A border may be best described as the long strip of earth close up against a wall or other means of protection. For instance, the strips running round the three walls of the ordinary suburban back garden would be called borders, while the circular plot in the centre, if there is one, would be a bed.

In making a bed, after having decided upon its shape, it is best either to peg the shape out upon the ground with sticks and string before commencing operations, or else plan it out in whitewash, like marking a tennis crease. This will prevent the possibility of a mistake. The simple precaution in making a border is to stretch a string taut between two pegs from end to end to ensure a correct edge, as nothing looks worse than an irregularly shaped border, unless the shape of the wall or garden demands it. If the whole garden is a new one and the ground has been treated on the lines laid above, no other preparation is necessary, but where it is proposed to cut a new bed or border out of an existing garden, the ground must be well worked as advised before planting.

The Front Garden. What to do with the front garden is a great source of perplexity to town gardeners, for it is only near the busy centres that the front garden proper finds a place. Most of them solve the problem by planting laurels and privets, a method which, if it has the merit of simplicity, is certainly not the best possible solution.

Though many flowers might be grown in such situations, particulars of which will be given in due course, there is always the danger of their being stolen; but a much wider range of trees and shrubs is available for town use, which have the advantage, moreover, of not being so greedy or exhausting to the soil as the laurel and privet. Of these, some are evergreen, and include rhododendrons, yuccas, azaleas, aucubas, hollies, and euonymus; while those that are deciduous (lose their leaves in winter) comprise weigela, ailantus, cotoneaster, philadelphus, mountain ash, sumach, elder, ash, plane, elm, and others of our native forest trees. Collections of some of the different sorts of ivies, too, will be found very useful in helping to beautify the town and suburban front gardens.

Simplicity should be the keynote of front gardening, and the idea of putting a monkey puzzle opposite the front door and surrounding it at a respectful distance with standard rose-trees is dying out, even as the rhododendron is beginning to oust the laurel from pride of place as a necessary adjunct to such arrangements.

Continued

THE WHOLESALE TRADE

Opportunities for Wholesale Trading. System in the Wholesale Trade. Commercial Travellers. Commercial Careers in the Colonies

FOR many business men the wholesale trade holds out inducements which retail shopkeeping cannot offer. The wider field of operation and the relative magnitude of individual operations are greater in the wholesale trade. For the employe the work is usually more agreeable, the hours shorter, and salaries quite as good, while there are prize posts, such as those of buyers, managers, and commercial travellers, which the retail trade cannot offer in the same proportion, so that promotion is more probable to a good man. But in the wholesale trade it is more difficult to establish oneself in business. The capital required is larger, and the skill in buying and selling is greater. Profits also are much lower, and in these days, when competition is keen to the point of warfare, special ability is required to organise and maintain a wholesale business at a high standard of efficiency. The increased tendency of manufacturers to sell direct to retailers militates against wholesalers. Few manufacturers refuse to give wholesalers better terms than they allow to retailers, but the difference between wholesale prices and retail prices frequently falls far short of a working profit. Hence the manufacturer who goes direct to the retail trade can usually cut out the wholesale merchant. In many trades this tendency to dispense with the services of the middleman, who was formerly the sole medium through whom the retailer did business with the manufacturer, is most pronounced, and the risk of embarking capital in such a wholesale trade is very great.

Opportunities for Wholesale Trade. The most promising fields for wholesale trading are in those departments of trade where the retailer cannot to a large extent purchase from the individual manufacturers on account of the small consignments which such a policy would demand. Thus the drug trade, many departments of the drapery trades, and the grocery trade offer far better prospects for wholesale ventures than, say, the glass and china trades and the boot and shoe trades. It may be agreed that where variety in stock is limited, and where, therefore, purchases of individual "lines" are fairly large, the wholesaler will have a hard fight to show reasonable profits, and this difficulty is likely to become accentuated.

The most promising centre for a wholesale trade to be run on as small a capital as possible is in the district where the goods to be sold are manufactured. Of recent years manufacturers have been given to hold their goods in stock ready for delivery. The wholesaler gets to know the manufacturers who pursue this policy, and he draws upon manufacturers' stocks as occasion calls, thus avoiding unnecessary stockholding in his own premises. The advantages of this system, from the wholesaler's point of view, are many and obvious. He does not spend money before he must—and, indeed, he may receive payment for much of his purchases before he is called upon to pay for them. Also, if capital be at command, the wholesaler close to the manufacturer is likely to have opportunities of purchasing below usual prices under special circumstances, and this is a prospect denied to the competitor whose headquarters are removed from the manufacturing centre. There may be occasions, however, when a good provincial centre with many villages within its commercial sphere may offer greater promise to a wholesaler. Under such circumstances stocks must be greater, as those of the manufacturer cannot be drawn upon at so short notice, but the proximity to the selling field gives the opportunity of closer relationship with customers, and enables the wholesaler to watch his trade more closely. These are the general considerations that enter into the question of location, and they may be applied to any special case that may arise.

System in Wholesale Trade. The wholesaler, more than the retailer, has need of system in his business. His success is dependent upon a perfect system to a greater extent than is that of his humbler confrère. The consumer must usually purchase in the district where he resides, so that the retailer, or the body of retailers in a locality, has a sort of monopoly; but the retailer is not restricted in this fashion, so that the wholesaler must justify himself by quality and service. Hence the more imperative demand for absolute system in the wholesale trade. The article on system for retailers [page 6056] and the articles on business management, which appear subsequently, may be studied by the wholesale merchant with advantage. The old system of selling at as high a price as possible and of accepting as low a price as compulsion demands is out of date. To accept certain prices merely because others do so is concentrated folly. Such a business system, or lack of business system, takes no account of working expenses, and the only sound business selling practice is where every individual transaction is made to stand upon its own legs, and to yield its due share of the margin necessary to pay general expenses and a little besides. Some years ago an important association of factors in one of the chief English trading centres decided that every one of their members should make a careful calculation to find out the relation of working expenses to turnover. Nearly every member was surprised at the result. The percentage ranged from 9 per cent. to 12 per cent., and the discovery caused much heart searching and mending of procedure.

"Cash with Order" Business. The most recent development in wholesale trading, and one which promises to expand, runs exclusively upon "cash with order" lines. The drug trade is an instance where this new development has manifested itself, and much perturbation has been caused in the ranks of the older houses of the competition of a firm who restrict their dealings to a limited number of articles of everyday demand, which they sell largely in original packages at very low prices, and only upon "cash with order" terms. The heavy expenses entailed by breaking bulk, by bookkeeping, and by giving credit, are obviated, and although the prices accepted are low, they are remunerative, and success seems to be attending the new system. This method has attractions for a good buyer with limited capital, but it must be confined to articles in everyday demand and of recognised standard quality.

District Agencies. All merchants, both wholesale and retail, desire to control the sale of specialities and proprietary articles in the districts where they operate. Sole sale usually means easy sale if the article is in public demand, and as a monopoly exists, there is no scrambling for the business. It is exceedingly hard to secure the sole agency for an article with an established sale. The makers would usually be unwise in their own interests if they were to restrict their trading to one middleman. The only way in which a district agency can be made profitable is by working up the sale in an unknown or little-known speciality. Hard pushing and judicious advertising may often dethrone an unremunerative but established proprietary article from popular favour, and there is then much profit for the house that has worked the substitute into popularity. The difficulty is to know what article can be pushed to success, and made to maintain success. There is on the part of proprietors of specialities a disinclination to grant sole agencies, and this is largely due to the fact that wholesalers seldom do such agencies justice. Knowing they have the field to themselves, they do not trouble to push sales energetically, and substitutes are sought and pushed by competing houses.

Retail Shops Owned by Wholesalers. Many shops doing only a retail trade are, in fact, owned by wholesale houses. Sometimes wholesalers, with more cash at command than they can profitably invest in their proper business, encourage the establishment of the retail shops, which become "tied" houses. The name on the fascia gives no clue to the identity of the actual owners. Sometimes, again, the wholesalers have the honour thrust upon them. One of their retail customers may become in their debt, and be unable to redeem himself. To save themselves, they take over the business and hold it permanently, or only so long as they must. They may decide to sell it or to place in it a man whom they believe capable of making it pay, with or without the option of buying out their proprietary interest. Such cases are often the opportunity of the good man without much capital but with ability and application. The advantage of retail shops owned by wholesalers is that they form a certain outlet for wholesale trading. Even if the retail shop, as such, should show no profit beyond bare expenses, the wholesale profits on the goods supplied to it may make it worth holding, and may make retail shops a wise business policy on the part of wholesalers. To cultivate such a trade requires a good deal of capital, and it should never be carried on with borrowed capital. The general management of such shops is similar to those of multiple or branch shops, which they really are, and these have already been discussed on page 5929.

Maintained Prices. Several business problems of recent development confront the wholesale merchant as well as the retailer. One of these is the question of maintained prices. Combination among retailers has caused many manufacturers to give adhesion to a scheme whereby selling prices may not be below a certain minimum, which is fixed so as to yield a reasonable profit to those handling the goods. Price maintenance affects the retailer more than the wholesaler because not all articles regarding which retailing restrictions prevail are price-maintained between wholesaler and retailer. But the wholesaler must understand clearly his liability in the matter. Where the manufacturer sells goods upon the condition that the wholesaler may sell them not below a certain minimum—and even when notification of this condition of sale is made only upon the invoice for the goods—the wholesaler is bound by such a condition if he accepts delivery of the goods, and liable to injunction and damages in the event of breach of the condition.

Trade Marks. In many trades, trade marks may be made important commercial assets. To make a trade mark valuable is to be able to secure for the article carrying it a greater profit than would otherwise accrue. Trade marks are not the peculiar property of manufacturers. Any middleman can, and many middlemen do, own valuable trade marks, which make them to some extent independent of specific manufacturers. If a wholesale merchant establish trade in an article carrying a trade mark which is his property, and if he be dissatisfied with the manufacturer who has been making the article for him, he can change his manufacturer, continuing to use the trade mark as before. If the trade mark were not his property, and if he had occasion to give up one manufacturer, he would require to take up something with a different trade mark—practically to introduce a new article to his customers—and any competing house could then make profit by taking up the manufacturer and the trade mark which he had discarded.

It is usual to apply for registration of a trade mark through an agent—commonly a patent agent —familiar with procedure. The agent's fee, including official stamps, is usually about £3. The official stamps come to half the sum named—to wit, 30s., being 10s. upon the application form, and 20s. upon registration. There are other fees payable only in certain cases—such as opposition to registration by another party. The necessary forms for making application for trade-mark registration may be had at any money order office in the United Kingdom. A pamphlet, "Instructions to Persons Who Wish to Register Trade Marks," may be had free on application to the Comptroller, The Patent Office, Trade Marks Branch, 25, Southampton Buildings, Chancery Lane, London, W.C.

Packing and Packages. In these days other considerations besides price and quality decide the placing of an order. One of the most important of the other points is the method of packing and the treatment of packages. Why do many people in this, as in other countries, prefer to sell Continental cups, saucers, and tumblers, for instance? Because the English articles are sent loose in boxes, casks, or crates, while the foreign articles are neatly wrapped in packages each containing half a dozen of one article, and because the packages can be neatly stowed on shelves, whereas the loose English style demands storing in tins or baskets. Again, why are American files and other tools sold as they are in this and other countries, where formerly the British article were the only kind found? Simply on account of American methods of packing. Instances might be multiplied, but these are enough. Whatever be the variety of merchandise under consideration the seller who can provide the buyer with the goods in a form to give him less trouble than is caused by competing goods offers a substantial inducement that is never lightly disregarded.

And so with packages. Many makers and merchants charge exhorbitant prices for packages so as to ensure their return. Wise men have, where possible, introduced the system of free packages, charging the expense of these against the general working expenses. We have never known a firm who adopted this system return to the old-fashioned method, which is surely the best evidence of its

practical value. The mere saving of trouble and expense of keeping record of the packing cases, or charging them and crediting them, is itself a saving and may be set off against the loss of their cost.

Invoices and Accounts. The conditions of payment should always be made clear upon all contracts of sale invoices and accounts. To leave the point uncertain is to leave the door open for disputes, upon which the lawyers grow fat. It has been held in law that the statement "five per cent. charged upon overdue accounts" gives the creditor the right to enforce such interest. It has the tendency to make debtors pay accounts when due so as to avoid the threatened penalty or the risk of its enforcement. It is usually wise on the part of the creditor not to insist upon such interest except in extreme cases, but to refrain from claiming it is an act of forbearance on his part dictated by considerations of policy in his desire not to alienate good though slow customers. When commercial travellers are not authorised to collect accounts a statement to that effect ought to appear prominently upon *all* invoices and account forms. Unless it can be proved that the debtor has had notice that accounts may not be paid to travellers, the creditor cannot fall back upon the debtor in the event of misappropriation by the traveller; but if due notice has been given to the debtor, he pays money to the traveller at his own peril and assumes responsibility for such money reaching the hands of the creditor.

Advertising for Wholesalers. Advertising by wholesalers must be on entirely different lines from retail advertising. The retail trade is exceeding jealous of any appearance of direct trading, and a wholesaler who advertises to the consumer lays himself open to the charge that he is seeking direct trade, even though he seeks publicity for proprietary goods which he intends to distribute through the retail trade only. Thus his advertising desires must be restricted to certain defined channels. The trade papers appealing to the retailers whom he seeks as customers are the most obvious agencies of publicity he can cultivate, but they have this objection—that if the wholesaler's field of trading is limited to one section of the country, the larger proportion of the money spent in them must fall on barren ground, as they have a very wide circulation. These considerations restrict the wholesaler's advertising to circulars and catalogues. His office should contain a card index with the names of all actual and potential buyers in his district, and he should circularise them periodically and persistently. He should especially draw their attention to all novelties and seasonable goods which he wishes to sell. Every circular should be illustrated, where possible, and retailing prices should be given, so that the retailer may show them to his customers if he wish. Catalogues should be issued periodically. These also should show retail prices, for the reason already given. The catalogues should be comprehensive, of convenient size, and well illustrated on good paper. Large-paper sheets should be avoided. They usually defeat their object, as the inconvenience of consulting them causes them to be rejected for catalogues in book form. The catalogue should be expansive if novelties are of frequent introduction, so that supplementary sections or leaves may be sent. All catalogues issued by one house should be of the same size. It is objectionable, from the user's point of view, when diversity of size and form are evidenced in several catalogues issued by one house. Anything that conduces to lessen the labour of the retailer is appreciated, and the wholesaler can do a good deal in that direction, the form of his catalogues and price lists being one.

In many trades periodical price lists—say, weekly or monthly—are advisable. Trades in which prices fluctuate a good deal—such as the provision and fruit trades—and where the nature of the sales changes with the season, are well cultivated by means of these. The objection urged against such price lists is usually that they merely afford a standard below which opposing firms cut prices. There is something in the objection, and in some trades the weekly or monthly price is not looked upon as giving the final price. Even those whose names appear on them do not adhere to the prices. This has come to be a recognised practice, so that while the value of the price list may be thereby decreased, it is not abolished. The periodical list forms a guide to the retailer. He recognises that he can buy at not more than the figures it gives, and in sending an order by post he is more likely to favour the firm whose name is on the price list before him than any other house.

The Commercial Traveller. When there is little chance that a young man will ever command the necessary capital to set up business for himself in the department of shopkeeping in which he has been trained, perhaps the best career he can seek is that of a commercial traveller. The life is interesting and pleasant. The moving about from place to place lends variety to the everyday work which is lacking in ordinary routine counter or office duties.

Commercial travellers should begin young, as the only school that turns out good commercial travellers is experience of the road. Commercial travellers usually graduate by promotion from the warehouse or desk in the manufacturing or wholesale establishment where they have been employed. Perhaps the best commercial travellers are those who have been schooled behind the retail counter. The experience gained there enables them to understand better or more quickly the retailers upon whom it is their business to call. The youth who in a small retail or mixed business is sent on the road to take a few "journeys" is launched on a career to which he will probably adhere throughout his active life. Even if he should elect to be an employer one day, he will probably be in a better position to do so than he would be if he had been behind a counter during the years he has spent on the road. He has more opportunity to save money as a commercial traveller than he would have as a shop assistant. Also the knowledge he can gain on the markets is greater than would be possible even as a buyer. He learns who are his competitors, gets to know what houses can do certain classes of goods better than his own, and becomes acquainted with the best terms obtainable—all of which knowledge stands him in excellent stead if he should at any time retire from the road and put up his sign.

Promotion to a Partnership. Partnerships are more often secured by travellers than by indoor assistants. The traveller possesses in himself a goodwill which makes him a desirable partner because the personal relations which have been established between the good commercial traveller and the members of the trade upon whom he had been wont to call enable him to take to any competing house to whom he way decide to transfer his services a considerable share of the trade which he has been in the habit of doing. It is for this reason that in the majority of the advertisements inviting

applications for the post of commercial traveller the stipulation is made that candidates "must have a good connection," a state of things which demonstrates the strength of the commercial traveller's position in the ranks of the mercantile army.

Qualifications for Commercial Travellers. The first essential for the commercial traveller is a thorough knowledge of the goods he sells. The statement is not superfluous. Many men sent on the road—and perhaps this applies more to the sons of principals—have a somewhat distant acquaintance with the articles whose merits they are sent forth to laud. It is frequently stated that the phenomenal success of many American travellers is due not to mere push or "bounce," but to intimate knowledge of the merchandise they offer. There is a good deal of truth in this supposition. We know of one large American firm who adopt a unique system of keeping their travellers up to date in knowledge of their trade. Over one hundred travellers are employed, and the business is a very large one, divided into many departments, yet the commercial travellers are noted for their wide acquaintance with all the numerous departments. Once a year the buyers spend a fortnight at the head office. They assemble for a good many hours daily and listen to lectures by the buyers of the different departments upon changes in the trade, novelties introduced, and other matters pertaining to their work on the road. Questions are asked, and samples handled, and the army of men goes forth equipped for another campaign upon the road.

The calling of a commercial traveller would be an excellent training for a diplomat. The traveller must be diplomatic to a degree, a walking embodiment of urbanity and persistence. He must be alert to take advantage of any opening to secure the interest of the prospective buyer, diplomatic in bringing him to the point of purchasing, and prompt in securing a firm order when assent has been obtained. No class of men are so subject to being snubbed, especially when their calls have to be made upon retailers, for these are often given to considering the traveller a nuisance, and many of them are not slow in expressing their opinions to the objects of them. The excessive number of commercial men on the road means that the individual retailer cannot do business with more than a fraction of them, and this gives the born diplomat his chance of gaining a point of vantage. A good presence is necessary to the commercial, a pleasant manner, and courtesy in spite of all rebuffs.

Salaries. The salaries of commercial travellers are as varied as the goods they sell, and nothing of much value to the individual case can be stated about their earnings. Young men claiming the dignity of commercial travellers to a small provincial establishment may earn not more than 20s. a week, whereas the important representative of a good house may earn many hundreds a year, and may possibly write his income in four figures. The average commercial traveller lies well between these two extremes. Those who earn less than £150 a year are in the lower ranks of the army of the road, and if they have ability should have not much difficulty in reaching and passing that modest figure, while those who earn over £400 a year are among the fortunate few, and the average man can seldom reach so high.

The extent to which the commercial traveller may charge personal expenses ought to be clearly defined. When the ground covered enables him to return home every evening, it is, of course, a matter of charging only his meals, train fares, and other methods of conveyance. Even then he ought to have a fixed allowance per day—say, half a crown plus fares. If he spend more, that is his personal concern, and if he spend less he should be allowed to pocket the difference. Such an arrangement obviates any inquiry into the disbursement of stray halfpence—an inquiry which is often considered by the commercial traveller to insinuate suspicion regarding his integrity and is, in any case, not in accordance with the dignified confidence with which he should be regarded by his principals. When the traveller is away on his journeys for days, weeks, or even months at a time, the same system ought to be followed—a daily allowance for personal expenses plus railway fares, or a larger allowance including railway fares. The scale of such an allowance must be decided by the nature of the work, by the necessity of carrying samples, of hiring conveyances for these samples, and of the need for stock-rooms at hotels. When many cases of samples have to be taken a frequent allowance is 20s. per day plus or including railway fares. One great advantage of a fixed allowance for a commercial traveller is that it discourages him to treat his customers, whereas a wider discretion may encourage him in this practice, which, on both the traveller's own account and on that of his firm, is by all means to be discouraged.

Working on Salary and Commission. We have considered merely the salaried commercial traveller. There is the commercial traveller, also, who works upon a commission basis. Sometimes the traveller may receive a salary plus commission, in which event the salary is, of course, smaller than it would be in the other event. This is an excellent arrangement for both parties provided the rules which are to decide the commission are clearly defined. The man has his salary for work done and his commission for the results of that work. He has a personal incentive to hard work, much stronger than he would have upon a salary basis only. But in such a case it should be clearly stipulated upon what business he is to receive commission. Sometimes the arrangement is that only orders actually booked by the traveller count as business done by him, and that orders sent direct from customers upon whom he calls are treated as if they had not been taken by him. Such an arrangement is scarcely fair to the knight of the road. It may cause him to urge his customers unduly when calling upon them—although some men will plead that travellers cannot do this—or he may have his customers address orders to him instead of to his employers, when delays may be caused by his absence.

The only truly satisfactory method is to treat a traveller's ground as his, and to credit him with every order coming from it whether he has taken it personally or it has been sent direct to his principals. It may be well to stipulate that business from customers upon whom he has never called should be excluded from the scope of this arrangement, as they cannot be said to have been directly influenced by him. Sometimes arrangements between principals and travellers whom commission affects stipulate that only a proportion of the commission—say half—is paid upon orders not booked by the latter personally, and in many cases such a condition is fair. Sometimes travellers carry side lines, and the trade and daily Press contain plenty of offers of side lines to travellers covering certain ground. If there be a specific or a tacit agreement that the services of the traveller are exclusively engaged by one firm, it is dishonest on his part to

accept any other commission, and, in the event of discovery, he is properly discharged. When a side line is carried by the consent of his principals, that, of course, is another matter.

Working on Commission Alone. Lastly, we consider the traveller who sells goods upon commission alone. His is often a hard fate. He usually carries a good many agencies, and when he has the ear of a customer, if the goods of one be not required, those of another may be. But there is usually a bitter fight for a connection before the commission man is able to consider himself in receipt of a livelihood. Agencies on commission go begging. The makers who offer them will not pay for the work put into opening new ground, and the rule of "no result no pay" causes the travelling commission agent to put in many hard days' work without reward. Embittered by discouragement he frequently throws up the sponge, and again the agency "on commission only" goes a-begging. Young men who think of adopting commission agency as a career we advise to be quite sure of a connection first. The only way of success without much bitter waiting and unremunerative hard work is to hold a salaried position for some time, then, knowing the ground and having a personal connection, to enter the commission field.

"Standing Treat." The highways of commercial travelling are strewn with the wrecks of men of ambition, ability, and promise who have succumbed to the temptations of the road. The rock upon which most careers have split has been that of drink. The virtue of hospitality is frequently exercised by the commercial traveller in the ordinary course of his business, and too often it has led to excessive tippling. This is not the place to preach total abstinence, but if any class of men have reason to protect themselves against the dangers of alcohol, it is that of commercial travellers. The young commercial who begins by the determination to refuse to do business which depends upon "treating," and who remains staunch in that determination, fortifies himself against the danger that has betrayed thousands of his fellows. This path once entered is not difficult to follow, but the opposite path once followed a little way can be left only with extreme difficulty. The former path also is the more remunerative. It gives evidence of a principle which commands the respect even of those who do not approve it. Fortunately, there is less occasion than formerly for urging the need of care in this respect, for the practice of "standing treat" is not nearly so general as it used to be.

Bribery. Commercial travellers know, perhaps better than any other class of the commercial community, the extent to which "greasing the palm" is practised in the struggle for business. Those who seek to fill their order books by bribery are, we believe, in the minority, but the minority is a large one. Even those who follow the practice are its slaves, not its advocates. The moral sense of most of them revolts against it, and they loathe a practice which degrades them as much as it degrades the recipients. The ironmonger's porter who takes stock of the hollow-ware that the gaps may be filled up may expect his shilling; the engineer in charge of a manufacturing plant may be restrained from complaining of the belting and lubricating oil when the traveller leaves half a crown behind him at every visit; and the buyer may even look for a commission upon his purchases. In every case the acceptance of bribes of this nature is a betrayal of trust, and from our condemnation we do not exclude the case of the buyer who is the recipient of boxes of cigars, turkeys, and cases of whisky as the Christmas festival draws near. There is an accepted opinion that the acceptance of presents in kind is not degrading, but this opinion is a very wrong one. The object of the giver, whether the bribe be money or money's worth, is the same, and no servant with a keen sense of independence and a true feeling of self-respect will accept any gift from any individual or firm to whom he is in a position to give orders or for whom he can influence orders from his employers.

Prevention of Corruption Act. The law has now strengthened the hands of those who are fighting against commercial bribery. The Prevention of Corruption Act (1906) came into force on January 1st of this year (1907). It is specially directed against bribes given in the course of business. It has not yet had the inward meaning of its several clauses elucidated by counsel in open court, so that there is some uncertainty whether it will be comprehensive and prevent all forms of commercial bribery. Its exact scope and limitations will be known only after specific cases have been tried under its provisions, but we may briefly recapitulate its chief sections, which are as follows:

1. If any agent corruptly accepts or obtains, or agrees to accept or attempts to obtain, from any person, for himself or for any other person, any gift or consideration as an inducement or reward for doing or forbearing to do, or for having, after the passing of this Act, done, or forborne to do, any act in relation to his principal's affairs or business, or for showing or forbearing to show, favour or disfavour to any person in relation to his principal's affairs or business; or

If any person corruptly gives, or agrees to give, or offers any gift or consideration to any agent as an inducement or reward for doing or forbearing to do, or for having, after the passing of this Act, done or forborne to do, any act in relation to his principal's affairs or business, or for showing, or forbearing to show, favour or disfavour to any person in relation to his principal's affairs or business: or

If any person knowingly gives to any agent, or if any agent knowingly uses, with intent to deceive his principal, any receipt, account or other document in respect of which the principal is interested, and which contains any statement which is false or erroneous or defective in any material particular, and which, to his knowledge, is intended to mislead the principal;

He shall be guilty of misdemeanour, and shall be liable, on conviction or indictment, to imprisonment, with or without hard labour, for a term not exceeding two years, or to a fine not exceeding five hundred pounds, or to both such imprisonment and such fine, or on summary conviction to imprisonment, with or without hard labour, for a term not exceeding four months, or to a fine not exceeding fifty pounds, or to both such imprisonment and such fine.

2. For the purpose of this Act, the expression "consideration" includes valuable consideration of any kind; the expression "agent" includes any person employed by or acting for another; and the expression "principal" includes an employer.

3. A person serving under the Crown, or under any corporation, or any municipal, borough, county, or district council, or any board of guardians, is an agent within the meaning of this Act.

A traveller is always unwise who runs down the goods offered by a competing house. Let him praise his own without the undue use of superlatives, but let him beware of his speech when speaking of other firms and the merchandise they offer. Few men can criticise their competitors and their competitors' wares without displaying the personal dislike which is usually associated with rivalry.

Motor-cars for Commercials. We cannot leave the subject of commercial travellers without mentioning the greater saving of time

which many of them will be able to effect by the use of motor-cars. For city work the motor shows to little advantage. For men who take with them a wide range of samples, it is undoubtedly good, as one call may be made after another with greater speed, and more work may therefore be done in a day by its use. Also the chauffeur is more available for assisting the traveller with samples and cases, because the motor-car may stand by the kerb without the attention required when a horse is between the shafts. But the most important sphere for the commercial traveller's motor-car is in country districts with infrequent train service. We are convinced that the commercial community do not yet realise what the motor-car may mean for them in this respect, and believe that there is a rich harvest for firms who adopt it as a conveyance for commercial travellers. There are many districts where there are many villages in greater or less proximity. In the aggregate these villages are equal to a large town, but it does not pay to work them under existing conditions. The train service between them is probably poor, and they would take two days to do properly. The motor-car may make it possible to do the group easily in one day. Shopkeepers in villages are often denied the privilege of buying from samples, and instead of the numerous sample-cases opened out before town buyers, a small hand-bag and a bulky catalogue serves for the village shopkeeper. The motor may be made a travelling sample-room, and the journey will cost less than it formerly did without samples.

Commercial Careers in the Colonies. This is a fitting place for a word to those who think about tempting fortune by embarking upon a commercial career in one of the Colonies or in a foreign country. Opportunity in a rapidly expanding country with a wide future before it is much more frequent, and the prospect of success much greater, than in this overcrowded competition-ridden homeland. At the moment, Canada and the Argentine Republic are the most promising oversea fields for commercial enterprise. The growth of both our great North American colony and of the South American republic is phenomenal, and is seldom appreciated by those who have no intimate knowledge gained by personal experience of the countries. Our other great colonies—South Africa, Australia, New Zealand, and the Indian Colonies—offer opportunities also, but the first named is at present under an eclipse of depression, the second is in the throes of evolution which do not encourage commercial ventures, and progress in New Zealand and India is of the slow order that is also in evidence in our own country. But Canada and the Argentine are undoubtedly the theatres where the agencies that bring success are to-day influencing events more than in any other parts of either hemisphere.

New countries are essentially the countries for young men. There is not the weary waiting for dead men's shoes; the stress of competition is not so keen as in the old land; and when opportunity comes, its hands are heavier with material gifts. Further, the fact that so many indifferent men—often wasters and incompetents—seek these far countries in search of riches or livelihood which they have been unable to find at home magnifies the chances of success to the really competent, energetic man who matches himself against them. The cry of the commercial employers in the Colonies is, "Send us good men. We are sick of your incompetents."

No one should set up business in the Colonies or in a foreign country without having had business experience in the country. He must find employment, gain experience, and then wait a favourable chance.

Cautions for Intending Emigrants. Sometimes positions abroad may be obtained before leaving home. More often they are obtainable only by the man on the spot, and he who would have them must go to the spot. When men are engaged in this country for such situations they are often required to enter into an agreement for a term of years—usually three—and have their passage paid. This practice is less common than it was, but it still prevails. It is not a good one. The new man usually finds that, although he has taken a seemingly lucrative position. viewed from the British wage standard, the remuneration which he has agreed to accept is less than that ruling in the market whither he has gone. He is tied up for the term of engagement, and cannot therefore improve his position should opportunity offer. He is also assisting to spoil the market in his new home. The two-pounds-a-week shop assistant in England is worth £25 a month in Johannesburg, and about as much in Winnipeg. And he need not think that he will be able to save the difference. The higher price of necessaries and luxuries makes that impossible.

It is always better for the shopman emigrant, if he is a good man, to pay his own fare and begin employment upon the understanding that he can leave at reasonable notice. If he is a man of inferior quality, he will be wise, however, to engage himself for a term of years if he can, otherwise he would find himself a member of the army of the unemployed, for Colonial business men do not keep poor servants long if there is a chance to replace them.

The Commercial Traveller Abroad. For the commercial traveller going abroad there are several things to be noted before going, or learned by bitter experience upon the field. Expenses are very much higher abroad than they are in England. In many colonial and foreign countries travellers must pay an annual tax, which is sometimes as high as £25 a year. The intending traveller must find out if he will have such a burden on him. Then the districts are usually thinly populated, and railway travelling is expensive, with business centres often far apart, so that the expense of a journey has no parallel to the cost of a commercial trip at home. In South Africa, for instance, few travellers representing home firms spend less than £600 a year in personal travelling and hotel expenses, making no count of salary. With this caution, commercial travellers intending to visit foreign countries may consider well the terms of employment offered them before they undertake a mission.

In countries where a foreign language is spoken, the traveller or the shop assistant ought to know that language. If he be ignorant of it, he need not go out on the chance of finding a position. Employers would not listen to him. If he go out to a position already secure, he will be of little use until he has obtained acquaintance with the vernacular, so that he will make himself proficient with all the speed possible. For instance, in the Argentine Republic, to which we have referred, Spanish is the language required, and no one need go there without a knowledge of that language.

SHOPKEEPING *concluded; followed by* BUSINESS MANAGEMENT

BUILDING REGULATIONS

The Public Health Act and Other Acts. Model Bylaws. Dictionary of Terms in the Finishing Trades

Continued from page 6028

By A. TAYLOR ALLEN

THE Public Health Act (1875) empowers sanitary authorities to make bylaws relating to new buildings.

(*a*) With respect to the structure of walls, foundations, roofs, and chimneys of new buildings, for securing stability and the prevention of fires, and for purposes of health;

(*b*) With respect to the sufficiency of the space about buildings to secure a free circulation of air, and with respect to the ventilation of buildings;

(*c*) With respect to the drainage of buildings, to water closets, earth closets, privies, ashpits, and cesspools in connection with buildings, and to the closing of buildings or parts of buildings unfit for human habitation, and to prohibition of their use for such habitation;

(*d*) As to the giving of notices, as to the deposit of plans and sections by person intending to construct buildings; as to inspection by the sanitary authority; and as to the power of such authority to remove, alter, or pull down any work begun or done in contravention of such bylaws

In 1877 the Local Government Board drew up a "model" series of bylaws for the guidance of local authorities. Series of annotated model bylaws are published by Messrs. Knight & Company.

It must be observed that bylaws made under the Public Health Act, 1875, cannot take effect until they have been submitted to and confirmed by the Local Government Board.

The following buildings are exempt from the operation of the bylaws relating to new buildings:

(*a*) Any building in his Majesty's possession, or employed or intended to be employed for his Majesty's use or service.

(*b*) Any county or borough lunatic asylum, and any building or part of a building belonging to the council of any county, city, or borough, and used, or intended to be used, for the detention of any prisoners.

(*c*) Any gaol, house of correction, bridewell, penitentiary, or other prison, and any building occupied or intended to be occupied by any prison officer for the use of such prison and contiguous thereto.

(*d*) Any building (not being a dwelling house) belonging to any person or body of persons authorised by virtue of any Act of Parliament to navigate on or use any river, canal, dock, harbour, or basin, or to demand any tolls or dues in respect of the navigation of such river or canal, or the use of such dock, harbour, or basin, and used, or intended to be used, exclusively under the provisions of such Act of Parliament for the purposes of such river, canal, dock, harbour, or basin.

(*e*) Any building (not being a dwelling house) erected or intended to be erected in connection with any mine, and used, or intended to be used, exclusively for the working of such mine.

(*f*) Any building erected, or to be erected, according to plans previously approved by the Land Commissioners for England of the Board of Agriculture under the Improvement of Land Act, 1864, or other Act or Acts for the improvement of land.

(*g*) Any building which may not be exempt by the operation of any of the preceding clauses of this bylaw and which may be erected, or may be intended to be erected, in accordance with such plan and in such manner as may be approved or directed in pursuance of any statutory provision in that behalf by one of his Majesty's principal Secretaries of State.

(*h*) Any building erected and used, or intended to be erected and used, exclusively for the purpose of a plant-house, orchard-house, summer-house, poultry-house, or aviary which shall be wholly detached, and at a distance of 10 ft. at the least from any other building, and which shall not be heated otherwise than by hot water, and in which the fireplace (if any) shall be detached with no flues of any kind within such plant-house, orchard-house, summer-house, poultry-house, or aviary

(*i*) Any building which shall not exceed in height thirty feet as measured from the footings of the walls, and shall not exceed in extent one hundred and twenty-five thousand cubic feet, and shall not be a public building, and shall not be constructed or adapted to be used either wholly or partly for human habitation, or as a place of habitual employment, for any person in any manufacture, trade, or business, and shall be distant at least eight feet from the nearest street, and at least thirty feet from the nearest building and from the boundary of any adjoining lands or premises.

(*j*) Any building which shall exceed in height thirty feet as measured from the footings of the walls, and shall exceed in extent one hundred and twenty five thousand cubic feet and shall not be a public building, and shall not be constructed or adapted to be used either wholly or partly for human habitation, or as a place of habitual employment for any person in any manufacture, trade or business, and shall be distant at least thirty feet from the nearest street, and at least sixty feet from the nearest building and from the boundary or any adjoining lands or premises.

(*k*) Any building erected, or intended to be erected, for use solely as a temporary hospital for the reception and treatment of persons suffering from any dangerous infectious disorder.

Thickness of Walls of Public and Warehouse Buildings. "Public building" means a building used or constructed, or adapted to be used, either ordinarily or occasionally, as a church, chapel, or other place of public worship; or as a hospital, workhouse, college, school (not being merely a dwelling-house so used), theatre, public hall, public concert-room, public ball-room, public lecture-room, or public exhibition-room, or as a public place of assembly for persons admitted thereto by tickets or otherwise, or used or constructed or adapted to be used, either ordinarily or occasionally, for any other public purpose.

"Building of the warehouse class" means a warehouse, factory, manufactory, brewery, or distillery:

Height not exceeding	Length.	Thickness of wall at its base.
Ft. 25	Any length	13½ in.
25 to 30	Not exceeding 45 ft.	13½ in.
,,	Exceeding 45 ft.	18 in.
30 to 40	Not exceeding 35 ft.	13½ in.
,,	Not exceeding 45 ft.	18 in.
,,	Exceeding 45 ft.	22 in.
40 to 50	Not exceeding 30 ft.	18 in.
,,	Not exceeding 45 ft.	22 in.
,,	Exceeding 45 ft.	26 in.
50 to 60	Not exceeding 45 ft.	22 in.
,,	Exceeding 45 ft.	26 in.
60 to 70	Not exceeding 45 ft.	22 in.
,,	Exceeding 45 ft.	4½ in. extra on thicknesses specified from base to within 16 ft. of top of wall
70 to 80	Not exceeding 45 ft.	22 in.
,,	Exceeding 45 ft.	4½ in. extra on thicknesses specified from base to within 16 ft. of top of wall
80 to 90	Not exceeding 45 ft.	26 in.
,,	Exceeding 45 ft.	4½ in. extra on thicknesses specified from base to within 16 ft. of top of wall
90 to 100	Not exceeding 45 ft.	26 in.
,,	Exceeding 45 ft.	4½ in. extra on thicknesses specified from base to within 16 ft. of top of wall

The Public Health Act (1875) provides no general power for a local authority to make a bylaw regulating the height of habitable rooms, but such a bylaw can be made by any local authority under Sec. 23 of the Public Health Acts Amendment Act, 1890 (an Adoptive Act). Recognising the sanitary value of such a bylaw, the following clauses, which have received their sanction, are given in extenso:

Every person who shall erect a new building, and shall construct any room therein so that it may be used for human habitation, shall comply with the following requirements:

If such room is not intended to be used as a sleeping room, he shall construct such room so that it shall be not less in any part thereof than eight feet in height.

If such room is intended to be used as a sleeping room, and is not an attic or a room wholly or partly in the roof of such building, he shall construct such room so that it shall be not less in any part than eight feet in height.

If such room is intended to be used as a sleeping room, and is an attic or a room wholly or partly in the roof of such building, he shall construct such room so that it shall be not less than eight feet in height on the average over the whole area of the room, and so that no part of such room shall be less than five feet in height.

Bylaws with respect to roofs and the structure of floors can also be made under the 1890 Act. New buildings in the metropolis are governed by the provisions contained in the London Building Act, 1894.

Building Line. As regards the question of building line, apart from the consideration either of street widening or air space, the only powers of urban authorities are those conferred by the following section of the Public Health (Buildings in Streets) Act, 1888. Without the written consent of the urban authority, no building (or part thereof) shall be erected or brought forward in any street, or any addition made thereto beyond the front main wall of the building on either side thereof in the same street. In considering what constitutes the front main wall of a house or building, all the circumstances of the case must be taken into consideration. The building must be looked at as a whole; its character, its position, its distance from the building which is being erected or brought forward on alleged contravention of the Act must be carefully considered. In the metropolis, the superintending architect of the County Council has power under the London Building Act (1894) to define the general line of buildings in a street.

Supervision of New Buildings by Local Authorities. Among the multifarious questions with which surveyors to local authorities have from time to time to deal in the course of their various duties not the least difficult are those connected with bylaws and that of exercising control over any new buildings that may be erected within the limit of their jurisdiction. This duty is in most towns largely determined by provisions contained in the Public Health Act (1875). To secure all the clauses of the bylaws being carried out, adequate inspection of buildings in course of erection is needed, and unless a staff of building inspectors is kept by a local authority, it is impossible to expect a town surveyor with his multitude of other duties to see that the bylaws are enforced. A question which naturally arises in the mind of the political economist is "How far is the local authority justified in controlling the individual action of a builder?" This has been answered in such a variety of ways as to bewilder the highest authority on the subject.

The following is a schedule of the thicknesses of external and party walls of domestic buildings as sanctioned by the Local Government Board:

Thickness of walls (domestic buildings).

"Domestic building" means a dwelling house or an office building, or other outbuilding appurtenant to a dwelling house, whether attached thereto or not, or a shop, or any other building not being a public building, or of the warehouse class:

Height not exceeding	Length.	Thickness of walls.
Ft. 25	Not exceeding 30 ft., and not comprising more than two storeys	9 in from base to top of wall
„	Exceeding 30 ft. or comprising more than two storeys	13½ in. below topmost storey 9 in. remainder
25 to 30	Any length	13½ in. below topmost storey 9 in. remainder
30 to 40	Not exceeding 35 ft.	13½ in. below topmost storey 9 in. remainder
„	Exceeding 35 ft.	18 in. lowest storey 13½ in. rest of wall below topmost storey 9 in. remainder
40 to 50	Not exceeding 30 ft.	18 in. lowest storey 13½ in. below topmost storey 9 in. remainder
„	Not exceeding 45 ft.	18 in. two lowest storeys 13½ in. remainder
„	Exceeding 45 ft.	22 in. lowest storey 18 in. next storey 13½ in. remainder
50 to 60	Not exceeding 45 ft.	18 in. two lowest storeys 13½ in. remainder
„	Exceeding 45 ft.	22 in. lowest storey 18 in. next two storeys 13½ in. remainder
60 to 70	Not exceeding 45 ft.	22 in. lowest storey 18 in. next two storeys 13½ in. remainder
„	Exceeding 45 ft.	4½ in. extra on thicknesses specified to all below the uppermost two storeys. Subject to the provisions respecting distribution in piers
70 to 80	Not exceeding 45 ft.	22 in. lowest storey 18 in. next three storeys 13½ in remainder
„	Exceeding 45 ft.	4½ in. extra on thicknesses specified to all below the uppermost two storeys
80 to 90	Not exceeding 45 ft.	26 in. lowest storey 22 in. next storey 18 in. next three storeys 13½ in. remainder
„	Exceeding 45 ft.	4½ in. extra on thicknesses specified to all below the uppermost two storeys
90 to 100	Not exceeding 45 ft.	26 in. lowest storey 22 in. next two storeys 18 in. next three storeys 13½ in. remainder
„	Exceeding 45 ft.	4½ in. extra on thicknesses specified to all below the uppermost two storeys

Continued

A SHORT DICTIONARY OF BUILDER'S FINISHING TERMS

AIR COCK—A tap to allow of the escape of air.
Anaglypta—A wall-covering modelled in relief.
Anchor Plate—A plate built into a wall to hold down some object.
Angus Smith's Solution—A preservative solution used for iron pipes.
Anti-syphon Pipe—An air pipe to counteract the tendency of traps to syphon out.
Apron—A strip of lead placed below a window, chimney, etc., and dressed on to the roof covering.
Arabesque Glass—A form of rolled glass with an ornamental pattern.
Axle Pulley—A pulley arranged in a vertical plate used in hanging sashes.
Automatic Flushing Cistern—A cistern arranged to discharge its contents as soon as it is filled.

BACK PUTTY—The putty placed between a pane of glass and the rebate of the sash.
Balance Weight—A weight used in sash frames to counterbalance the frame.
Barff's Process—A method of protecting iron by forming a coating of black oxide.
Bases—Those pigments which give opacity and body to paints.
Bastard Flatting—A flatting coat to which a little clarified oil or size has been added.
Bearing Plate—An iron plate used between a strap and a piece of timber.
Bell Board—A board on which a series of bells are attached.
Bib-cock—A form of cock which delivers water from the end of a pipe.
Blister—In painted work small parts of the paint that have become separated from the surface covered and raised.
Blown Joint—A soldered lead joint made with a blowpipe.
Bobbins—Boxwood balls used in bending lead pipes.
Bolt—A curved piece of wood used in bending lead pipes; a metal fastening for a door catching in a staple or thimble.
Boot Boiler—A form of boiler used at the back of a kitchen range.
Box Girder—A girder having two parallel webs.
Bracketing—Piece of wood to receive lathes for plaster cornices.
Brad—A small nail with a head on one side only.
Brazing—The joining two pieces of metal by means of brass solder.
Bringing Forward—Painting portions of work one or more extra coats before general painting.
British Plate—Plate glass cast and afterwards polished.
Brunswick Black—A material formed of asphaltum and turpentine and applied to iron.
Bulb Iron—Iron rolled with one flat and one cylindrical flange.
Bullet Latch—A latch formed with a spherical catch like a bullet.
Bullion—The centre of a sheet of crown glass.
Burlap—A woven material formed of jute.
Burning Off—Removing paint by applying heat to the surface.
Burning In—Melting solder to fit lead in a raglet.
Burnt Joint—A lead joint formed with lead in place of solder.

CABIN HOOK—A freely-moving hook attached to a staple or plate.
Calcothar—Red oxide of iron.
Cames—Strips of lead having an H section used in lead glazing.
Cantilever—A beam built into a wall and supported at one end only.
Casement Fastener—A metal fastener to secure a casement to the frame.
Cast Iron—Iron that has been melted and cast in a mould.
Cathedral Glass—Plain, tinted glass used in lead glazing.
Cat Ladder—Light iron ladders used for giving access to roofs.
Ceiling Block—A block of wood used for attaching a gas pendant to a ceiling.
Cesspool—A sunk outlet to a lead gutter.
Chimney Bar—A wrought-iron bar built in under the arch of a chimney opening.
Chequer Plate—An iron plate with a raised chequered surface.
Circulating Pipe—A pipe through which hot water from a boiler is circulated.
Cleaning Eye—An opening inserted in pipes and traps to facilitate cleaning.
Clearcolle—Thin liquid glue used on porous surfaces before whitewash.
Clips—Metal bands placed round a pipe to fix same to woodwork.
Clout Nails—Flat-headed nails.
Coach Screw—A long screw of uniform diameter and with a square head.
Coarse Stuff—A mixture of lime, sand and hair for first two coats in plastering.
Cobweb Grating—A form of grating used as outlet to lavatory basins.
Coburg Varnish—A pale oil varnish.
Cockle Furnace—A furnace of thick iron used for heating air.
Collar—A lead disc temporarily fixed round a pipe during wiping a joint to catch the superfluous solder.
Coil—A pipe bent to and fro to give a large heating surface at any desired point.
Compo—A general term given to cement used for coating brickwork.
Composition Nails—Nails made of various alloys to avoid corrosion.
Concrete Float—A thick, heavy float used in finishing concrete paving.
Copper Bit Joint—A soldered joint made with a copper bit.
Copper Nails—Nails made of copper, usually in the form of clout nails.
Core—A thick iron bar fitted under a handrail; the rough centre for a plaster moulding.
Cottar—Wedge-shaped keys.
Countersunk Joint—One finished with a splayed head flush with the plate.
Cover Flashing—A strip of lead fixed into a wall and covering the top of a flashing.
Creeping—The slow movement of lead downwards on a steep roof.
Cross-garnet Hinge—A hinge in the form of a ⊢.
Crown Glass—Glass blown in globular form and afterwards flattened.
Crystal Glass—A very pure white quality of sheet or plate glass.
Cup-and-ball Joint—A joint giving free rotary motion, used for chandeliers.
Cups—Small brass cones fitted into wood beads to receive the heads of screws.
Cutting Wheel—A circular knife used in trimming wallpapers.

DADO—A horizontal division at the base of a wall.
Darby—A two-handled plasterer's float.
Dead Lock—A lock having only one bolt operated by a key.
Dished—A slightly hollowed bottom formed in lead-lined sinks and cesspools.
Distemper—A material similar to whitewash, but mixed with colouring pigment.
Double-arm Pendant—A form of gas pendant having two arms.
Double Laths—Laths of extra thickness.
Double Size—Size of twice the usual strength.
Double-swing Bracket—A gas bracket having two arms, both with movable joints.
Dovetail Lathing—A sheet of metal bent into a series of dovetail grooves.
Draw-off—A tap by means of which water may be drawn from a pipe.
Drawn Pipes—Lead pipes produced by machinery without any joint.
Drip—An abrupt change in the level of a lead flat.
Drip Pipe—A pipe used in steam heating systems to get rid of condensation water.
Drop Handle—A handle which is hinged to lie close against a door when not in use.
Dryers—Substances added to paint to assist the absorption of oxygen.
D Trap—An old form of trap, shaped like a D.
Dubbing Out—The process of forming a core for plaster mouldings.
Dummy—A tool used by the plumber in pipe bending.

EARS—Flat projections cast on iron rain-water pipes for fixing them.
Eaves Gutter—A gutter to take rain-water fixed at the eaves.
Economiser—A metal shield to close the opening between a grate and the hearth.
Elbow—A socket joining two pipes at right angles.
Embossed Glass—Glass that has been ornamented by chemical process.
Escutcheon—A small shield placed round a keyhole opening.
Espagnolette Bolt—A long double-action bolt used to secure French windows.
Eye—A metal ring into which a bolt may be fitted.
Eye-plate—A plate by which an eye may be attached to woodwork.
Expanded Metal—Metal sheets perforated and drawn out to form a kind of netting.
Expansion Joint—A form of joint allowing of movement due to expansion.
Expansion Pipe—A pipe in a hot-water system to carry off or contain excess of water due to expansion.
Expansion Tank—A tank in a hot-water system to hold excess of water due to expansion.

FALL-DOWN STOP—A form of gate stop that is lowered when not in use.
Feather-edge Rule—A rule one edge of which is splayed off to a thin edge.
Feed Cistern—A small cistern to keep a boiler supplied with water.
Fine Stuff—A mixture of lime putty with a little sand and hair.
Finger Plate—A plate fixed to either face of a door above or below a lock.
Finial—An ornamental termination to a gable or hip.
Fining Float—Small float for working plaster mitres, etc.
Fire-bar—The horizontal bars which carry the fire in a grate, boiler, etc.
Fish-plate—An iron plate used in forming a fished joint.
Flake White—A form of pure white lead made in England.
Flange—The tension and compression members in an iron girder.
Flanged Joint—A lead joint formed with a flange below it to support the pipe on a floor.
Flashed Glass—White glass with a film of coloured glass overlaid.
Flashing—A strip of lead used to make watertight the joint between a sloping roof and a vertical face.
Flatting—A coat of paint that is finished without gloss.
Flitch—An iron plate placed vertically in a flitched beam.
Float—A flat wooden instrument for working the final coat in plastering.
Floating Rule—A long rule used in forming screeds and floating surfaces between screeds.
Floor Spring—A spring for automatically closing a door, fixed in the floor.

Flow Pipe—That portion of a circulating pipe from the boiler to the highest level.
Flush Bolt—A bolt let into a door or window so that the face is flush with the wood.
Flush Handle—A handle sunk into a door so as to be flush with its face.
Flushing Tank—A tank the whole contents of which are discharged at one time.
Fluted Sheet—Sheet glass rolled with ribbed rollers, producing flutes.
Foil—Thin leaves of copper and other metals, applied like gold leaf.
French Nails—Long thin wire nails with flat heads.
French Polish—A mixture of shellac and spirits of wine for polishing hard woods.

GALVANISED IRON—Iron covered with a coating of zinc.
Gasket—Strands of rope or cord driven into the joints of pipes.
Gas Tar—See *coal tar*.
Gauge—A measure of thickness of wire and metal; to mix materials in exact proportion with water.
Gauge Board—A board on which plasterers' materials are mixed.
Gauged Stuff—Coarse or fine stuff with which plaster of Paris is mixed.
Gauge Hook—A tool used by plumbers for shaving lead surfaces.
Gauge Rule—a rule used for forming sunk or raised plaster surfaces.
Gauging Trowel—A trowel used for gauging plasterers' stuff.
Gelatine Mould—Moulds formed of gelatine for casting plaster enrichments.
Gib—A bearing iron used in connection with cottars.
Gilding—A process of applying gold leaf to surfaces.
Glaziers' Putty—A mixture of whiting and linseed oil.
Gold Size—A material applied to surfaces to be gilded.
Governor—An automatic control to regulate the pressure of gas in buildings.
Grainers' Comb—A metal comb used to produce graining.
Graining—Finishing a painted surface to match the grain of wood.
Ground Brush—The brush used by painters for large surfaces.
Ground Glass—Glass the surface of which is rendered obscure by grinding.
Gudgeon—The term applied to the eye of a hinge.
Gutter Pipe—The pipe through which the contents of a gutter are discharged.

HACKING OFF—The process of removing old plaster.
Hacking Out—The process of removing broken glass and old putty.
Hair—In plastering, the long hair from the backs of oxen.
Hand Float—Small floats, usually of pine, used in plastering.
Hangers—The struts employed in trussing a timber beam.
Hasp—A hinged, slotted plate passed over a staple and secured with a pin or padlock.
Hawk—A small board with a handle used for gauging and holding plasterers' stuff.
Heel—In pipe bending, the outer side of the curve.
Hit-and-miss Grating—One of which the openings can be closed by sliding a perforated plate.
H-Iron—Iron rolled so as to have an H section.
Holding-down Bolt—A bolt used to secure any object to an anchor plate.
Hopper Closet—A closet in the form of a funnel.
Hydrant—A stand pipe to which a hose may be attached.

INGRAIN PAPER—Papers coloured throughout in their manufacture.

JAPAN—Lead paint mixed with varnish dried at a high temperature.
Japanese Gold Size—A preparation of gum anime and linseed oil.
Jhilmil—A form of metal lathing.

KEEN'S CEMENT—A preparation of plaster of Paris treated with alum.
Keying—The scoring of the surface of plaster to secure adhesion for the next coat.
Kicking Plate—A metal plate fixed to the bottom rail of a door.
Killed Spirit—Spirits of salts in which zinc has been dissolved.
King Bolt—An iron bolt taking the place of a king post in a compound truss.
Knotting—The process of killing or covering knots in woodwork before painting.
Knuckle—The projecting portion of a hinge through which the pin passes.

LAC—A resinous substance obtained from the East Indies.
Lacquer—A varnish made with methylated spirit.
Lapped Joint—In lead work a joint in which one sheet is covered by the edge of the next.
Larry—A rake used for mixing hair with coarse stuff.
Latch—A fastening which may be opened with a handle instead of a key.
Lath and a Half—A term applied to extra stout laths.
Laths—Thin strips of wood used as a groundwork for plastering.
Lattice Girder—A girder of which the web is formed of iron lattice work.
Laying—Another term for rendering in plaster work.
Laying Trowel—A large square trowel used in rendering.
Lead Lights—Lights formed of small panes connected by lead cames.
Lead Safe—A tray of lead formed to catch any overflow water.
Levelling Rule—A rule used by plasterers in levelling ceilings.
Lignomur—A wall-hanging formed of wood fibre.
Lime and Hair—Another term for coarse stuff.
Lime Plaster—A term signifying that plaster is formed with lime.
Lime Putty—Pure lime run with water and allowed to settle.
Lime White—Chalk lime mixed with an excess of water, used as a wash.
Lincrusta Walton—A wall decoration executed in relief.
Litharge—Another term for oxide of lead.
Luxfer Glass—A special glass formed with prismatic projections on one side.

MACK PARTITION—A patent partition formed of plaster and reeds.
Mandrels—Cylinders of soft wood varying in length.
Margin Trowel—A parallel-sided trowel for plaster margins.
Massicot—A superior kind of oxide of lead.
Mastic—A resinous gum obtained from the Mediterranean.
Metallo-ceramic Joint—A patent joint for uniting lead pipe to earthenware.
Middling Lead Pipe—A pipe intermediate in weight between light and heavy.
Milled Lead—Sheet lead that has been rolled out.
Minium—Another name for red lead.
Mortise Lock—A lock that is inserted into a mortise formed in the thickness of a door.
Muffled Glass—Glass formed with a wavy surface.
Muffling—Covering a running mould with plaster to reduce its section.
Muffling Plate—A metal plate used to reduce the section of a running mould.
Muller—A kind of pestle used in grinding paint.
Muranese—A form of obscured glass.

NIB—The upper edge of a plasterer's running mould.
Nipple—The screwed end of gas pipe to receive the fitting.
Norfolk Thumb Latch—A latch operated by a lever which can be depressed by the thumb.

OIL POLISH—A finish produced with linseed oil.
Overflow—An outlet allowing water to escape on reaching its level.
Over Graining—A thin additional coat over ordinary graining.
Overcast Joint—One on which a series of facets are formed after wiping.
Oxide of Iron Paint—Paint in which oxide of iron forms the base.

PACKING PIECE—Iron slabs of various thickness used in levelling girders on stanchions.
Palette—A thin wooden board to receive paints used in decorative work.
Palette Knife—A long, flexible blade used in mixing up colours.
Painter's Torch—An apparatus for producing a flame for burning-off.
Pan Closet—An old form of w.c. in which a pan was employed to receive the contents.
Panel Float—A small float used for laying and smoothing work in panels.
Panel Trowel—Resembles a laying trowel, but is smaller.
Parian Cement—A white cement prepared from plaster of Paris and borax.
Parliament Hinge—A hinge having the form of an H.
Patent Size—A preparation of gelatine.
Pebble Dash—Another name for rough coat.
Pedestal Closet—A modern form of w.c. with basin and trap exposed to view.
Pivot—A projecting pin working in a socket.
Plaster of Paris—A fine white plaster prepared from gypsum.
Plate Glass—Glass poured hot on to a table and rolled out.
Pneumatic Bell—A bell operated by the compression of air.
Polished Plate—Plate glass that has been polished.
Polishing Trowel—A trowel used in finishing the setting coat of plaster.
Pot Metal—Glass which is coloured throughout its substance.
Pouring Stick—A short, grooved piece of wood to convey melted solder to the back of a joint.
Picking Up—Applying coarse stuff to walls, partitions, or cubings.
Priming—Covering a wood surface with the first coat of paint.
P-Trap—A trap the general form of which resembles a ᑭ.
Pulp Paper—The commonest class of wallpaper.

QUADRANT STAY—A stay bar for openings and arches having a quadrant form.
Quarries—Glass cut into small pieces for lead glazing.

RADIATOR—A closed metal vessel having a large superficial area for radiation.
Raglet—A chase cut in stonework to receive lead flashings.
Rain-water Gutter—A channel to receive rain-water from the eaves of a building.
Rain-water Head—An open vessel above the pipe to receive the discharge from a gutter.
Rain-water Pipe—A metal pipe used to convey rain-water.
Red Lead—An oxide of lead, usually in the form of a red powder.
Reducing Pipe—One reduced from a larger to a smaller diameter.
Reflector—Reflecting surface used to alter the direction of rays of light.

Register Grate—One having a flap, or register, between the grate and the chimney.
Render—The process of laying coarse stuff or cement on solid walls or ceiling.
Return Pipe—That part of a circulating pipe between the highest level and the boiler.
Ribbon Joint—One in which a band of solder is formed round the joint.
R.I.J.—Abbreviation for rolled iron joist.
Rim Lock—A lock attached to the face of a door.
Rising Butts—Those that lift the door slightly as it opens.
Rising Main—The pipe taken up to supply a cistern.
Roll—The method of forming a longitudinal joint between two sheets of lead.
Rolled Plate—Plate glass that has been rolled to produce a fluted surface.
Rough Cast—A method of finishing external plaster with pebbles or shingle.
Rough Cast Plate—Cast plate rolled with a smooth roller.
R.S.J.—Abbreviation for rolled steel joist.
Rubber Cone—A union formed of rubber.
Rubbing Down—The process of rubbing each coat of painted work.
Rule—A strip of wood varying in size and form used in floating plaster.
Running Rule—Wood strips fixed as guides for running moulds.
Running Mould—Moulded profiles by means of which mouldings in plaster are formed.

SADDLE-BAR—A metal bar used to give support to lead lights.
Sanitary Paper—Wallpaper printed in oil colours and washable.
Sash Fastener—A metal catch to secure one sash to another.
Sash Lift—A metal hook or plate by which a sash is lifted.
Sash Tool—The brush used in painting sash-frames.
Sash Weight—Metal weights used to counterbalance the sash and its glass.
Satin Paper—Wallpaper having a polished, satin-like surface.
Scagliolер—A special form of coloured plaster used in imitation of marble.
Scouring—Working over plaster surfaces with a hand float.
Scratch—A tool used in scratching or scoring plaster surfaces to form a key.
Scratch Tools—Small tools of various shapes used in finishing plaster enrichments.
Screed—A strip of plaster laid as a guide for floating.
Seam Roller—A small roller used in smoothing the joints in paper-hanging.
Seamed Pipe—A lead pipe formed out of sheet lead with a soldered joint.
Setting—The process of laying and finishing the final plaster coat.
Setting Coat—The last coat in plastering, formed of fine stuff.
Service Pipe—A pipe conveying water from the supply to a fitting.
Sgraffito—Successive thin coats of coloured plaster incised and cut to give pictorial effects.
Shave Hook—A tool used in shaving lead-work.
Shaving—The process of removing a thin layer of lead to provide a bright surface.
Sheet Glass—Glass blown in the form of cylinders and afterwards flattened.
Shoe—The outlet of a rain-water pipe over a gulley.
Side-arm Roller—Resembles a seam roller, but will work close up to a projecting surface.
Silicate Cotton—A fibrous non-conducting material produced from iron slag.
Single-swing Bracket—A gas bracket having one movable arm.
Size—A liquid preparation of glue.
Size Kettle—A kettle with water jacket, in which size is melted.
Skimming Float—A large float used for laying setting stuff.
Slag Wool—See *silicate cotton.*
Slipper—The face of a running mould.
Slop Sink—A sink intended to receive bedroom slops.
Smoothing Roller—A broad roller used in paper-hanging.
Smudge—A preparation used by the plumber in soiling.
Snap Rivet—One formed with a spherical head.
Soakers—Sheets of lead inserted under slates or tiles, and turned up against a wall.
Soil—Another term for smudge.
Soiling—The process of covering with soil those parts of lead work to which solder is not required to adhere.
Soil Pipe—A pipe for conveying away the contents of w.c.'s.
Soldered Dot—A method of securing vertical lead sheets to woodwork or stone.
Soot Door—A small iron door and frame inserted in a smoke flue.
Sparge Pipe—A pipe arranged to distribute a discharge of water over a wide area.
Splash Stick—A small wood or iron stick used in upright soldered joints.
Sprig—A small metal brad. used by glaziers.
Sprigging—Temporarily securing panes of glass with sprigs.
Stanchion—A perpendicular support under a girder.
Standing Waste—A waste pipe standing up within a cistern.
Stand Pipe—A vertical pipe fitted with a tap for drawing off water.
Stay Pipe—A metal bar used to secure a window when open.
Stencil—A pierced plate for painting designs that repeat.
Stepped Flashing—One cut to allow of the upper edge being turned into successive brick joints.
Step Setter—A tool used in forming stepped flashings.
Stiffeners—In built girders pieces of angle iron used to stiffen the web and flanges.
Stippling—Finishing a painted surface with the end of a paint-brush.
Stock—The backing for the profile plate in a running mould.
Stopcock—A valve used to shut off a supply.
Stopped End—A closed end to a rain-water pipe.
Stopping—The process of filling up small holes in woodwork or plaster.
S-trap—A trap the outlet of which is in the form of an S.
Strap—A narrow plate used in securing timber joints.
Strap Hinge—A hinge for heavy gates, fixed to them with iron straps.
Striking Plate—The metal plate into which the bolt of a lock is inserted.
Stucco—A somewhat vague term applied to several plastic mixtures.
Swan-neck—A bent pipe connecting a rain-water gutter and pipe.
Syphon Box—An apparatus used to collect water from gas supply.
Syphon Closet—One in which the contents are removed by syphonic action.

TACKY—The condition of paint or varnish which fails to dry properly.
Taft Joint—A wiped lead joint resembling in form a copper bit joint.
Tar Paint—A paint for iron formed with tar, lime and naphtha.
Tension Rod—An iron rod used in trussing timber beams.
Throat—In pipe-bending, the inner side of the lead.
Tie-rod—A metal rod replacing a tie-beam in a compound roof.
Tingle—A broad strip of stout lead used to hold down the edges of lead sheets.
Tinning—The process of covering a copper bit with solder.
T-iron—Iron rolled in the section of a T.
Toe—The lower end of the stock of a running mould.
Touch—A piece of tallow candle is used to touch lead surfaces after shaving.
T-piece—A form of union between two horizontal and one vertical tubes.
Traversing Rule—A rule used for forming screeds in gauged or setting stuff.
Trimming Knife—A knife used for trimming wallpapers.
Trowelled Face—A plaster face highly finished with a trowel.
Trumpet-mouth Waste—A waste pipe the mouth of which is enlarged like a trumpet.
Turnbuckle—A fastening of iron or brass turning on a pivot.
Turn Pin—Wood cones used for enlarging ends of lead pipes..
Tynecastle Canvas—A material moulded in relief on canvas for covering walls.

UNDERHAND JOINT—A wiped joint on a horizontal pipe.
Union—A screw joint to unite a pipe to a cistern or a lead and iron pipe.
Universal Joint—A ball-and-socket joint.
Upright Joint—A wiped joint on a vertical pipe.

VALLEY GUTTER—A gutter formed in the angle between two roofs.
Valve Closet—One in which the outlet of the basin is closed by a valve.
Vehicles—The liquid with which pigments are mixed to form paint.
Ventilating Stove—A stove provided with a hot-air chamber and air inlet.

WALL HOOK—An iron spike with a curved end that will grip a pipe.
Warning Pipe—One that gives notice by dripping when a cistern is full.
Washable Distemper—Material resembling distemper, but which may be washed.
Wash-down Closet—One in which the bottom of the pan is continued into the trap.
Wash-out Closet—One in which the contents of the pan are washed out into the trap.
Water Stain—A material used for altering the colour of woodwork.
Water Waste Preventer—A cistern using only a limited amount of water at each discharge.
Wax Moulds—Used by plasterers for casting enrichments.
Wax Polish—A glossy surface produced on wood with the aid of wax.
Web—The vertical member of an iron girder.
Weeping Pipe—A pipe which allows water to drip slowly.
Welted Joint—One in which two metal sheets are folded together to form a joint.
White Lead—A carbonate of lead, the base of many paints.
Whitewash—A mixture of whiting, water and double size.
Wired Glass—Glass in which wire netting is embedded.
Wiped Joint—A joint formed with solder by means of a cloth pad.

ZINC PAINT—A paint of which the base is zinc white.
Zinc White—An oxide of zinc.

HARBOURS AND DOCKS

The Action of Waves and Tides, and their Consideration in Harbour Construction. Different Classes of Harbours

By A. T. WALMISLEY

SCARCELY any branch of engineering presents so many difficulties as that which deals with marine structures, and in the prosecution of this study the student cannot do better than peruse carefully the various papers dealing with marine work which are published in the volumes forming the Minutes of Transactions of the Institution of Civil Engineers, and which furnish accounts of the most recent improvements.

The consideration of the action of the waves is of primary importance in the design of works exposed to the action of an open sea. Waves near a coast do not attain the dimensions of those in the open sea, and the reference to waves as "mountain high" is a popular error. Waves have to be considered by the harbour engineer in connection with harbours, docks, and coast protection, and may be classified as: (1) tidal waves, (2) wind waves, (3) ground swells, (4) breaking waves.

Tidal Waves. The great tidal wave of the ocean, which causes the rise and fall of the water on a coast, is an element that must be taken into consideration. The maximum effect due to a tidal wave occurs at the time of high spring tides when accompanied by heavy on-shore gales. The height to which the water rises above the beach is increased during gales, and varies from 3 ft. to 4 ft. according to locality. The effect of gales is greatest when the wind, after blowing along the coast in the same direction as the main stream of the flood tide, changes about the time of high water to an on-shore direction. When a tide is rising the water for some distance from the coast is flowing towards the shore, and when falling, is flowing from it. A tidal wave moves along the deep water of the open sea at a greater velocity than in shallow water near the coast. The crest of a wave in the open sea is therefore in advance of that near the shore, resulting in an oblique lateral movement along the shore. The tidal wave becomes a wave of translation when it encounters the obstruction caused by the shoaling of the shore, and is reflected back, setting up a series of small oscillations or waves, which break on reaching the low-water level.

VELOCITY AND PRESSURE OF THE WIND

Feet per minute.	Miles per hour.	Force in lb. on sq. ft.	Description.
88	1	·005	Hardly perceptible
352	4	·079	Gentle wind and breezes
440	5	·123	
880	10	·492	Good breeze
1,320	15	1·107	
1,760	20	1·970	Brisk gale
2,640	30	4·429	High winds
3,080	35	6·027	
3,520	40	7·870	Very high
3,960	45	9·960	
4,400	50	12·300	Storm
5,280	60	16·710	Great storm
7,040	80	31·490	Hurricane
8,800	100	49·200	

The rise and fall of tide, irrespective of wind, is effected not merely by a vertical swelling and depression or rising and fall of water, but by a series of small waves, which vary in height according to the conditions of tide and beach, and which are absent from the shore only when absorbed by larger waves during gales.

Influence and Prevalence of Wind. Although the wind is the primary cause of the attacks to which all shores are exposed, its influence is excited through the waves raised by it. It is necessary to consider the direction of the prevailing winds, at what seasons they generally blow, and the distance that the wind travels unimpeded, so that the entrance to the harbour may be made to face the proper direction for vessels entering and leaving.

Wind Waves. Wind waves are produced by wind blowing on the surface of the sea and are pure undulations. The form of wave transmitted towards the shore has no forward progressive movement until the margin of a shore is reached. The common form of wind waves in open sea is cycloidal, but shore waves assume more the form of an ellipse.

Ground Swell or Rollers. By ground swell or rollers is implied a product of wind waves which are generated at some distant part of the ocean, and which travel across the ocean shorewards, and form long, low undulations. Their effects extend to a greater depth than that of ordinary waves, and they exert greater power of transmission nearer the bottom than shorter waves in the same depth. The long waves formed by ground swell on approaching shallow water, where depth is constantly diminishing, are increased in height and velocity, and exert more powerful and a greater percussive effect on a sea-wall or cliff than ordinary wind waves, and the back-wash proves more destructive to a beach.

Breaking Waves. Breaking waves are produced owing to the water becoming shallow, and being no longer able to complete the undulation under ordinary conditions. A wave breaks when it reaches water of a depth approximately equal to its height from trough to crest. A wave on breaking assumes a progressive accelerated horizontal motion, and is capable of carrying forward with it any material with which it comes into contact, and on receding down the slope has a strong erosive and transporting power. The mean level of the sea at the place where a wave breaks on the shore is raised by the action of an on-shore wind, and is further increased by the impetus of the waves, hence the surface of the water forms a slope upwards towards the shore, causing an undercurrent towards the sea. An off-shore wind produces an off-shore current.

The height, length, and velocity of waves are governed by the depth of the water. The force and percussive effect of a breaking wave on a cliff or sea wall are in proportion to the cube of the depth of the water in which it breaks.

The percussive force is diminished in proportion to the angle at which the wave strikes the object with which it comes into contact, either horizontally

or vertically. The force of waves on a beach varies with the slope, the higher the beach and shallower the water, the less the eroding and transporting force.

The length of a wave is the distance measured from the top of the crest of one wave to that of the next. The height is the vertical distance from the bottom of the trough to the top of the crest.

As regards the velocity of waves—short waves whose lengths are not greater than the depth of the water have a velocity depending sensibly only on their length and proportional to the spread of their length. Long waves whose lengths are greater than the depth of the water have velocity depending sensibly only on their depth, and are proportional to the square root of the depth. The velocity of a wave ceases to increase with the depth beyond a depth equal to the length of the wave. Long waves in deep water have the greatest velocity, irrespective of their height.

The question of the movement of material at great depth has given rise to much discussion. The movement of sand, stones, etc., in water of considerable depth is generally due to tidal currents, aided by wave action. There occurs a movement at the bottom of the deep-water channels that intersect the sands lying off the shore, but the sand is drifted backward and forward only with the flood and ebb tide.

The late Sir John Coode stated (Minutes of Evidence, Select Committee on Harbours of Refuge, 1851) that he "found the shingle of the Chesil Bank disturbed by wave action, during the heaviest gales, at a depth of eight fathoms, the shingle thus disturbed being of large size."

Movement of the Particles Forming Waves. Passing waves give an observer the impression that they are advancing towards the shore, but instead of passing onward, each wave oscillates between certain points, the distance between which bears a fixed relation to the length of the wave between crest and crest. Only the form and energy of the wave are transmitted and not the water, except to a certain extent in the case of waves of translation.

The dynamical effect of waves striking a plain surface is not easy to estimate; but when a gale is subsiding more damage is often done to sea walls, etc., during that period than when at its height, owing to the waves becoming more regular and in a way steadying themselves as the force of wind decreases, and thus throwing their full weight against any opposing structure.

Fetch is the distance in any direction which is freely traversed by waves driven by the wind.

Crests on waves are formed in the open ocean by the wind urging the top of the wave forward at a greater velocity than the body of the wave, and causing that portion of the wave to break by pushing it over. Waves sometimes carry their crests for a long distance, and become dangerous to vessels of small size. These waves do not disperse, and cannot be regarded as ordinary breakers. There is no reliable formula for calculating the height of waves during strong gales. The height of spray on broken water is often shaken about instead of the actual wave. The greatest height may be taken as between 40 and 50 ft.

Tides. Tides are due to the combined attraction of the sun and moon. They exert their greatest attractive effect upon that part of the water which is immediately opposite to, and therefore nearest, to them.

Tides are mainly governed by the moon, in spite of the much greater force exerted by the sun at the earth's surface, and are influenced by the moon and follow her apparent passage round the earth, due to the earth's rotation. Two lunar tides are experienced in the course of a day. Morning and evening tides, ordinary and equinoctial tides, and summer and winter tides, are affected by variations in distance of the sun, moon, and earth from each other, and also by declination.

During each lunar month, the sun, moon, and earth are in line, and effective lunar and solar attractions are combined, raising the water on the two opposite sides of the earth, and this increased rise creates what is known as a *spring tide*.

Equinoctial Spring Tides. These occur in March and September, when the sun is vertical over the equator, and its attractive power is then greatest. When the lunar tides at new and full moon coincide with the solar tides about this time, which they do more closely now than at other times, these abnormally high and low tides occur. During each lunar month also the sun is once in a position at right angles to the moon as regards the earth, the lunar tide is reduced by the opposing action of the sun, by the extent of the solar tide, and the result is called a *neap tide*.

Considerable influence is exerted by the wind upon the tides by raising or depressing the sea-level along coasts. A strong on-shore wind increases the normal rise of the tide and prevents it from falling to its full extent. An off-shore wind produces the opposite result. Furthermore, it is found that changes in atmospheric pressure affect the tidal rise by altering the local pressure upon the sea. The weight of the atmosphere at the earth's surface equals a pressure of 15 lb. per square inch, and is equivalent to nearly $8\frac{3}{4}$ tons per superficial yard.

Barometers record atmospheric pressure by comparing it with the height of a column of mercury, which it is capable to balance. The weight of mercury is approximately thirteen times that of sea water; therefore, a fall or rise of 1 in. would represent an elevation or depression to the extent of 13 in. According to Lord Avebury, a rise of 1 in. in the barometer causes a depression of the tide at London of about 7 in., and of 11 in. at Liverpool.

Double tides are caused by portions of the tidal wave reaching a locality by different routes, such as takes place at Southampton. The portion of the tidal wave which passes up the western channel, being deeper and more direct, reaches Southampton earlier than the portion of the tidal wave passing up the eastern channel, thus forming a double tide.

Currents. No general rules regarding currents can be laid down, as each place has its own peculiarities. For information as regards the flow and velocity of currents it is usual to refer to the Admiralty charts. Ocean currents are produced by the difference of the temperature at the equator and near the Poles. The density of the heated water being reduced, it flows towards the Pole, and becomes replaced by an undercurrent of cold water travelling towards the tropics.

Tides occur twice in every 24 hours and $50\frac{1}{2}$ minutes. When a place is on the same side of the equator as the moon, the tide which is produced while the moon is *above* the horizon, as already explained, is greater than while the moon is under the horizon of the place; but when a place is upon the opposite side of the equator to the moon the effect is reversed. In midsummer, the afternoon tides are higher than the morning tides. In the winter, the morning tides are usually the highest.

Beardmore gives the following table for finding the height of the tide at any period after high water.

HEIGHT OF TIDE AFTER HIGH WATER					
Time from high water.		Multiplier.	Time from high water.		Multiplier.
Hours.	Minutes.		Hours.	Minutes.	
0	00	1·000	3	00	·500
0	30	·975	3	30	·375
1	00	·916	4	00	·258
1	30	·841	4	30	·158
2	00	.741	5	00	·083
2	30	·625	5	30	·025

The rule is to multiply the range of tide for the day by the factor opposite the hour at which the height is required. Suppose, as our example, that the total rise of tide at Dover on the 12th April was 20·4 ft., high water made at 3 p.m. What was the height of tide at 4 p.m.? $20{\cdot}4 \times {\cdot}916 = 18{\cdot}68$ ft.

Harbour Regulations. Parliament has from time to time authorised a considerable expenditure of national funds for harbours and breakwaters useful for the Navy, and they are therefore deemed, very properly, to be of national rather than of local importance—as, for example, at Portland, Plymouth, Dover, Holyhead, and Chatham.

A General Act, called the "Public Works Loan Act," authorises advances to be made to such undertakings. Acts of Parliament are necessary for harbour works of large magnitude. Small undertakings, where it is not proposed to acquire land for the purposes of the works, are carried out without the expense and trouble of a special Act, under Provisional Orders of the Board of Trade. All such legal documents are cheaper than engineering works, and are not always executed within the prescribed limits of time. Harbour improvements, or the construction of a dock required for the special interests of a mercantile port, may be sometimes constructed and paid for by local or municipal capitalists, or, in addition, outside aid may be obtained.

Harbour Revenues. Works are generally made directly remunerative by subjecting vessels, merchandise and passengers, to a tax or toll for the use of the improved accommodation. The revenue from harbours and docks is generally levied in the shape of dues on vessels, calculated according to weight, bulk, or value, and sometimes as a poll tax on passengers. The necessary money may be provided through the ordinary means of a joint stock company, or by means of a harbour trust. In the former case, the net revenue will be applied to the payment of a dividend to shareholders, who will naturally endeavour, by keeping down expenditure and maintaining high rates, to obtain as much profit as possible. In the latter case, the money is raised on bonds bearing a fixed rate of interest for the payment of which the revenue of the undertaking is pledged, the profits beyond what is necessary for this fixed rate being applied to the extension or improvement of the works, also to a sinking fund for the redemption of the bonds and then to the reduction of the tolls. As examples of the first system, joint stock companies own the docks of London, Southampton, Hull, and Plymouth. The Clyde Trust, the Mersey Docks and Harbour Board, the Dublin Board, the Belfast Board, and the Dover Harbour Board, are examples of the second system.

Different Classes of Harbours. We have (1) harbours of refuge and anchorage breakwaters, which consist of one or more breakwaters, arranged so as to form a safe roadstead, easily accessible in all states of weather and tide to the largest vessels; (2) deep water and tidal harbours for commercial purposes, in which an arrangement of piers or breakwaters, or of both, enclose and tranquillise a water area enabling vessels to be moored at the quay walls or wharves, forming the inner sides of the piers; and (3) canted or curved piers, where vessels lie under the lee of the cant and the sheltered side of the pier is finished as a quay. Where the coast lies open to a heavy sea it is found necessary to make a double harbour, the entrance to the inner basin being protected by the outer works.

The shore between high water and low water belongs to the Crown, unless alienated by special rent to the lord of the manor or frontages, and no groynes or erections of any kind for coast protection may be constructed below high water without their consent. The influence of the protection of one portion of a foreshore by such artificial means should be considered in its effect upon adjoining foreshores which may not be as well protected. The terms of reference to the Royal Commission on Coast Erosion, which is now sitting, are:

To inquire and report:

(*a*) As to the encroachment of the sea on various parts of the coast of the United Kingdom, and the damage which has been, or is likely to be, caused thereby; and what measures are desirable for the prevention of such damage.

(*b*) Whether any further powers should be conferred upon local authorities and owners of property with a view to the adoption of effective and systematic schemes for the protection of the coast and the banks of tidal rivers.

(*c*) Whether any alteration of the law is desirable as regards the management and control of the foreshore.

(*d*) Whether further facilities should be given for the reclamation of tidal lands.

Depth of Water. It has been found in actual experience that harbour entrances formed by converging jetties have, in general, attained a better depth of water than those where parallel jetties have been adopted. The force of a scouring current makes itself felt against the shallowest point of the channel, while shoals formed in the wider sheltered area inside are easily removed by dredging. The harbour engineer must anticipate vessels 1,000 ft. in length and drawing 40 ft. of water, and in all modern harbours must dredge accordingly.

The system of producing scour by a single jetty can be resorted to only in very exceptional circumstances. At the same time, trumpet-shaped entrances cannot be recommended. The superiority of converging jetties, kept low in places to ensure the filling of the estuary at every tide, consists in the small interference with littoral currents. They tend to produce scour round the projecting point formed by the piers, and they concentrate the current at the most critical point of the channel. Uniform width in a channel tends to produce uniform scour and to improve the discharge of flood waters. Hence, the advantage of a pier upon both the sides of a harbour entrance.

Continued

STRENGTH & SPEED OF SHIPS

The Strength of Material and Attachments. Distribution of Structural Material. Speed and Resistance of Sailing and Steam Ships. Steering

By Dr. J. BRUHN

When the designer has ensured that his ship will float at the required draft, and that she will float in the upright position, then he has to make sure that she will possess the third essential quality—namely, such structural strength as will admit of her being exposed to all the ordinary forces met with in her trade. The designer is, however, in most instances to a large extent relieved of the trouble and responsibility of himself ascertaining if his ship will have the required strength. The classification societies, such as Lloyd's Register, Bureau Veritas, British Corporation, and others exist with a view to ensuring, in the interest of owners and underwriters, that their ships possess ample structural strength, and the standard of efficiency which they provide is usually so high that the ship designer or builder practically leaves this question entirely to them. These societies provide definite dimensions (scantlings) for the various structural items according to the size, type, and arrangement of the ship. Their wider experience with regard to this particular point enables them to determine what the dimensions of the material ought to be more readily than it would usually be possible for the individual designer to do; but the latter must, on the other hand, sometimes investigate the question of strength independently. In doing so he uses the same broad principles upon which the tabulated rules of classification societies have been based.

Strength of Material. The strength of a ship depends, in the first instance, on the strength of the material employed. At the present moment there is for practical purposes only one material used in shipbuilding—namely, mild steel. Chemically, this consists almost solely of iron with a very small quantity of carbon and traces of silicon, sulphur and phosphorus. Its strength is usually supposed to be measured by the number of tons required to pull asunder a bar with a section of one square inch. For ordinary shipbuilding steel, this, the tensile strength, varies from 26 to 32 tons per square inch. This figure is, however, in itself no criterion as to the suitability for its intended purpose. It is only when the material is otherwise satisfactory, when it is elastic, ductile, flexible, etc., that the tensile strength may be taken as a guide to its efficiency. In fact, it is often undesirable to have a very high tensile strength, as that is not usually associated with good qualities in other directions. To such an extent is this the case that practically all specifications for steel contain an upper as well as a lower limit for the tensile strength of the material. The steel is nearly always tested at the maker's works with a view to its quality being guaranteed before it is forwarded to the shipyards. Strips are cut off the rolled plates, and some are pulled asunder in a machine with a view to ascertaining the tensile strength, which is the breaking load divided by the sectional area of the test piece. Other pieces are subjected to bend tests which afford a fair criterion as to the elasticity and ductility of the material. Good steel is an excellent material for shipbuilding purposes, but, at the same time, a lighter material with the same ductility would be still better even if the tensile strength were somewhat less.

Strength of Attachments. The structure of a large steel ship is necessarily made up of a great number of individual plates and angles, which have to be attached to one another by rivets. The strength of a ship does not, therefore, depend solely on the strength of the building material, but also on the strength of the means whereby the individual pieces of material are joined together. Excellent steel is comparatively easy to obtain, but it is of little use if the attachments are of inferior quality. It is therefore the designer's duty to arrange the riveting of his structure in such a way that it shall be as nearly as possible equal in strength to the plating.

There is a variety of ways in which plates and angles have to be joined in a ship. Figure 150 shows the simplest. It is here merely a question of attaching the ends of two plates which may be subjected to tensile stresses. The pull across the entire width of the one plate must be transmitted through the rivets to the other plate. The strength of the plate is represented by its sectional area or by the product of its width (b) and thickness (t), together with the tensile strength of the material (q). The strength of the rivets is represented by the aggregate sectional area of the rivets and the strength of their material per square inch (q_1). It would be of no use to have the strength of the riveting greater than that of the weakest point of the plate, which is where it is injured by the rivet holes. Let the diameter of the rivets be d, their number n, and their distance apart, centre to centre, p. If the strength of the riveting is equal to that of the perforated plate, then

$$\cdot 785 d^2 \times n \times q_1 = (b - nd) \times t \times q,$$

or, as $$n = \frac{b}{p},$$

$$\cdot 785 d^2 \times \frac{b}{p} q_1 = \left(b - \frac{b}{p} d\right) t \times q;$$

or $$\cdot 785 d^2 q_1 = (p - d) \times t \times q.$$

The plates were supposed to be subjected to pull, in which case q, the tensile strength of the material, is a proper factor of the right-hand term. The rivets, it will be observed, are not subjected to a pull in this case, but to a shearing action; q_1 does therefore not represent the tensile strength of the rivet material, but the shearing strength, which may be taken as 80 per cent. of q. The above equation may then be written

$$\frac{\cdot 628 d^2}{(p - d)} = t.$$

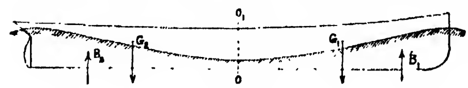
Spacing of Rivets in Practice. From this it will be seen that the diameter of the rivets and their spacing should depend on the

thickness of the plates to be attached. Larger rivets may be adopted with wider spacing, or smaller ones with closer spacing. In practice, it is found desirable to use relatively much larger rivets in thinner than thicker plates, because in the former case the actual size of rivet is such that it can be knocked up with ease by manual power, whereas the rivets for the thicker plates would be so large that it is better, where hand riveting is adopted, to have more and smaller individual rivets. Roughly, the diameters of the rivets in steel plates of the thickness t are equal to $\frac{1}{2} + \frac{10}{16}t$ in., which shows that they are relatively small for the greater thicknesses, and the necessary strength of the attachments has, in those instances, to be provided by means of additional rows of rivets. One row may be enough for the thicknesses up to $\frac{1}{4}$ in; two may be needed when the thickness is $\frac{1}{2}$ in.; three when $\frac{3}{4}$ in.; and four when 1 in. There are other points except the mere consideration of strength that govern in practice the sizes of rivets, such as the necessity to have a spacing of the rivets that will admit of the edges of the plates being caulked and made efficiently watertight. In a ship the edges of the plates as well as the butts have to be riveted together, but the attachment need not usually be so strong in the former as in the latter case. There are a number of other forms of riveted attachments—as, for instance, those between the frames and shell plating, and between the beams and the deck plating—which must also be strong enough to resist the stresses brought to bear upon them. In a general way, it may be said that it is the riveted attachments that are the weak points in a ship's structure, and when any straining does occur at sea, the result is nearly always slack and leaky rivets, and very rarely actually fractured plates.

Distribution of Structural Material. The question of the strength of ships is not merely one of sound material and effective attachments: it is also one of sufficient material and efficient distribution. It will be self-evident that the strength of the ship depends in some measure on the amount of the structural material; but it will also depend largely on the arrangement of the steel plates and angles. The most efficient distribution is that which admits of the greatest strength being obtained with the minimum weight of material. In order to determine this distribution, it is necessary to deal with the forces that act on a ship. These are, of course, of a very variable character. Some forces are at a maximum when the vessel is in dry dock, others when she is in the light condition, and others again when she is loaded. It should be the maximum probable forces in each instance that should govern the amount of strength to be provided at any particular place in the structure.

A ship cannot be made strong enough to resist any forces, any more than a bridge can be made strong enough to bear any load that may be placed upon it. It may be possible to make a vessel of moderate size strong enough to rest on a soft river bottom; but it is quite impracticable to make a large ship strong enough to bump on a rocky shore. Except in the case of a few small vessels, specially designed to rest on the bottom of harbours and such places, it ought to be the conditions at sea that should govern all questions of strength. The waves of the ocean cannot apply the local pressure to a ship which it is possible for a ragged ledge of rocks to do; but they can at the same time cause very heavy distributed pressures to act on the structure. Just as the problem of the stability of ships and land structures was seen to be in reality the same, so the question of the strength of ships will be found, when closely examined, to be very much the same as the problems the civil engineer has to solve on land. To the superficial observer the question of the structural strength may appear a more intricate one at sea than on terra firma; but in many respects it is really a less difficult one, although in itself an exceedingly complex one.

Forces Acting on a Ship. The forces that act on a ship's structure and tend to strain it, are gravity, inertia, and the pressure of the supporting medium. A loaded ship will usually have the weight of her structure and cargo more or less uniformly distributed throughout her length. The support or buoyancy is also distributed in much the same manner. This means that the weight is at each point practically directly balanced by the supporting upward pressure of the water. When the vessel is placed among large ocean waves, the conditions change considerably. The weight of the structure and cargo remains always the same, but the supporting pressure will increase in way of the



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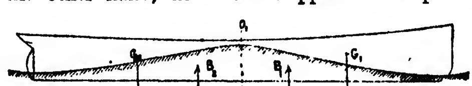
crests of the waves, where the water is piled up, and it will decrease at the hollow of the waves, where the draft is diminished.

Figure 151 shows a vessel as she may float for a moment when waves of her own length are passing by. It will easily be realised that the support of the buoyancy is, in this instance, chiefly confined to the ends of the vessel, and the ship will have a tendency to sag down in the middle, just as a loaded bridge, supported at its ends, would do. The centre of gravity of the whole ship must still be over the centre of buoyancy, and both of these points may be taken to be in the line OO_1. The tendency for the vessel to sag down causes a bending moment to be set up at OO_1. Looking at the forward half of the vessel, it will be apparent that there is an upward moment about OO_1 equal to the product of the forward buoyancy multiplied by the distance of its centre B_1 from OO_1. There will, likewise, be a downward moment equal to the weight of the forward half of the vessel multiplied by the distance of its centre of gravity from OO_1. If these moments balanced, then there would be no moment at OO_1, but if one is greater than the other, then there will be a moment at OO_1, which must be borne by the structure, and must be balanced by a similar but opposite moment caused by the weight and buoyancy of the after end of the vessel.

Sagging and Hogging Moments. In the illustration shown the upward moment of the buoyancy is clearly greater than the downward moment of the weight, with the result that the end of the vessel is lifted relatively to the middle, or inversely the middle is sagging down in relation to the ends. Such moments are called sagging moments. If, on the other hand, the vessel happens to be poised



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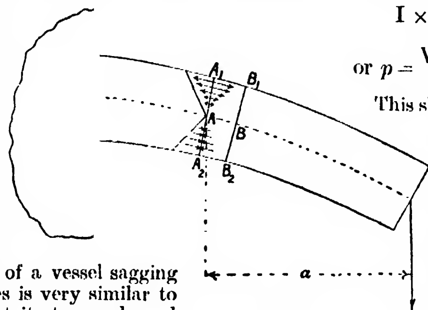
instantaneously on the crest of a wave, as shown by 152, then it will be understood that there is an unnecessarily large amount of support amidships,

and very little at the ends of the vessel. While the moment of the weight of the forward half of the vessel remains the same as before, the moment of the buoyancy is reduced, owing to its centre B_1 moving closer to OO_1.

In these circumstances the weight moment will be the greater of the two, and the result will be a downward moment about OO_1 equal to the difference between the moments of weight and buoyancy, or equal to half the weight of the ship multiplied by the horizontal distance between the points B_1 and G_1. As before, this bending moment must be borne by the structure at OO_1, and be balanced by that of the other end of the vessel. In this case the middle of the vessel tends to rise and the ends to droop, which would cause the outlines of the vessel to assume the form of a hog's back, hence the name of *hogging* moment for the resulting bending tendency. The case of a vessel sagging with its two ends on waves is very similar to that of a bridge supported at its two ends and that of a vessel hogging to a bridge of the cantilever type supported at the middle only. All that is needed to determine the sagging and hogging moments at OO_1 is an estimate of the weight and centre of gravity of the forward portion of the vessel, and of the forward displacement and its centre of buoyancy. A ship may meet with a variety of waves, but those of its own length produce the most severe straining actions. For the purpose of calculation it is usual to assume the wave to be of a trochoidal profile and of a height equal to one-twentieth its length. As the waves are getting longer, they become relatively lower, and it would be more correct to assume a proportionally lower wave for the larger ships.

Bending of Girders. A ship is simply a hollow girder, and will bend as such a structure does when loaded. In the bending of a beam, as shown by **153**, the top fibres of the material are stretched and the bottom ones compressed, while midway between the two there will be some which neither stretch nor contract. The two cross sections, as A_1A_2 and B_1B_2, originally parallel, will, therefore, when the beam is bent, be slightly angled, and A_1 B_1 will be longer than A B, while A_2B_2 will be shorter. The bending action is therefore made up of simple tension and compression. The tension in the upper half of the beam, say from A to A_1, will produce a moment about A, and similarly the compression on the lower half will also produce a moment about A tending to turn in the same direction—namely, that which is opposite to the motion of the hands of a watch. The greater the tension and compression the greater the moments will be. Together they must be equal to that of the weight W multiplied by the distance from the section considered. It will therefore be seen, as might be expected, that the larger the bending moment the larger the tension and compression will be. A tensile or compressive stress is the tension or compression respectively per square inch of material measured, say, in tons.



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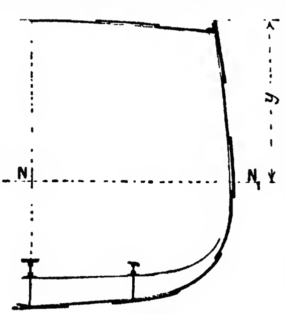
The straining moment at A_1A_2 depends on the moment of the section and on the stress on the material. If the stresses were of equal magnitude over the whole section, then the moment would simply be the moment of the area multiplied by the stress, but as the stress is increased uniformly towards the edges of the beam the moment is the product of the moment of inertia I of the section of the beam at A_1A_2 and the maximum stress p divided by its distance y from the point of no stress, A. We therefore have the following:

$$I \times \frac{p}{y} = W \times a,$$

$$\text{or } p = W \times \quad \times y$$

This shows that the maximum stress on a girder is equal to the bending moment (W × a) at the point considered multiplied by the distance which the highest stressed fibres are from the point of no stress, the whole being divided by the moment of inertia of the cross section of the material. Exactly the same formula holds good in the case of a ship. The bending moment may be estimated as described above.

Moments of Inertia of Sections. The moment of inertia of the material section is estimated as follows. Let **154** represent a half cross section of a ship. A horizontal line NN_1 is drawn at about one-third the vessel's depth above the top of keel. The sectional area of each of the individual plates is then determined and tabulated. Each of these sectional areas is then multiplied by the distance of its centre of gravity from NN_1, and also by the square of this distance. All the sectional areas of the plates and angles both above and below NN_1 are then added together, while the products of the areas and their distances from NN_1 are added up separately for the parts above and below NN_1. The difference between the two sums of these products represents the moment of the section with reference to NN_1, and if this be divided by the total sectional area the result is the distance of the centre of gravity from NN_1. It so happens that the horizontal line of no extension or compression passes through the centre of gravity of the section, and this line xx_1, called the *neutral axis* of the section, may therefore be drawn parallel to NN_1. The moment of inertia I of the section is the sum of all the products of the areas and the squares of their distances from NN_1 with a deduction of the product of the total area and the square of the distance between xx_1 and NN_1. The point of maximum stress is the one farthest removed from xx_1, which in nearly all vessels will be at the deck, either at the middle or at the side. Its distance from the neutral axis is usually designated y, and the maximum stress is therefore, M being the bending moment:



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$$p = \frac{M}{I} y$$

Effect of Depth of Girder. This is a frequently occurring expression in all strength

calculations. It will be observed that the stress at any place will vary as the bending moment and inversely as the moment of inertia of the section. Furthermore, it will vary as the distance from the neutral axis. For a given amount of material the moment of inertia will be larger the deeper the section is. The deeper vessel is therefore, other things being equal, the stronger. From the fact that the strength depends on the moment of inertia it will further be evident that it will be advantageous to place as much as possible of the material at the top and bottom of the structure, leaving only a sufficient amount of plating at the side of the vessel to resist the other forces acting there. The stress estimated by the above formula is that on an uninjured section of material, and if the stress in way of the rivet-holes is desired, it is necessary to multiply p by the ratio $\frac{s}{s-d}$ where s is the spacing of the rivets centre to centre and d their diameter.

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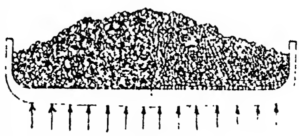
Floors, Beams, and Girders. Just as the ship is, as a whole, a large girder, so all its parts are dependent for their strength on smaller girders. At the bottom of the vessel the floors form girders across the ship to carry the cargo and resist the pressure of the water. At the sides of the vessel the frames form girders from bottom to deck, and at the top the beams form girders supporting the loads on the deck. Each floor may be looked upon as a girder in conjunction with part of the shell plating, as shown by **155** for a single-bottom vessel and by **156** for a ship with an inner bottom. It will act as a beam supported at its ends, in this instance the sides of the ship, and it will be loaded with the weight of cargo on the top and with the pressure of the water below, as shown by **157.** If these forces are equally distributed and of equal magnitudes there will be no bending tendency. On the other hand, if the weights carried are in excess of the upward pressure, or if the latter is in excess of the weights, then there will be bending moments, which must be resisted by the floors. The strength of these is represented by the moment of inertia of the sections shown in **155** and **156,** and what was said with regard to the moment of inertia of the midship section of the ship applies equally here—the deeper the girder the stronger it will be for the same amount of material, because the greater the moment of inertia will be. The water pressing against the side of a vessel tends to bend the frames inwards, and there is usually no inside pressure tending to counterbalance the outside effort. The frames will therefore act more or less as a girder fixed at the bottom and at the decks and loaded with a pressure gradually becoming greater as the draft is increased [**158**]. The beams support the loads they carry between the pillars and the frames, as indicated by **159.** The beams of the uppermost deck carry a load only momentarily when a wave may be breaking upon them, but they have to be of considerable strength to resist the effect of such bodies of loose water. Water-tight bulkheads are stiffened in the same manner as the side of the vessel to resist the pressure of water that may accidentally have got into one of the holds.



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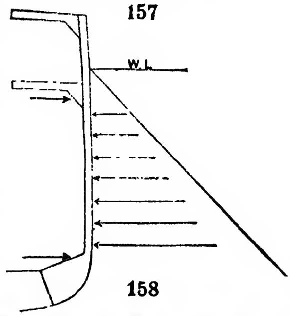

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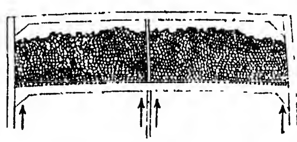

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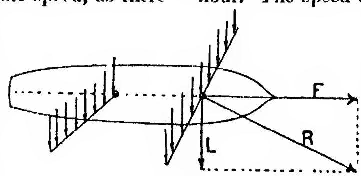
Value of Experience. From the above a rough idea may be gathered as to the nature of the strength required in a ship, but it will be readily understood that a great many other complicated straining tendencies are at work in a ship when she is at sea, rolling and pitching among waves. The effect of these may be more or less acurately estimated, but it is in any case usual to allow a fair margin for strength for unforeseen eventualities. The experience gained by existing vessels is of the greatest value in forming a reasonable judgment as to the amount of margin necessary to prevent straining under exceptional circumstances. It should always be the aim of the designer to ensure the necessary strength with the minimum amount of material; because every ton of weight saved in the structure of a vessel means a ton more carrying ability.

The ratio between the dead-weight carried by a vessel and the weight of the ship complete is a measure of the efficiency of the distribution of the structural material. At the present time it is 2 to 3, but it is a figure which has been steadily increased, and will continue to be increased, as there are still ample opportunities of improving the structural designs of ships.

Speed of Ships. Speed is not a primary necessity for a ship like stability and strength. At the same time, some measure of it is absolutely essential in any efficient ship. It would always be in the owner's interest to have a vessel as fast as possible, provided the weight of machinery and coal remained the same. As the speed increases, so does, however, also the weight of the machinery and coal necessary to drive her, which means that the dead-weight is reduced. It is a problem for the owner and designer to solve to what extent the cargo-carrying capacity of a vessel for a particular trade should be sacrificed for the sake of gaining speedier transit. Where passengers only are carried, the dead-weight is not so important, and higher speed is therefore the rule in such cases, although even here the cost of the coal burnt and the upkeep of the more powerful engines and boilers place a limit to the economical speed.

Speed of Sailing Vessels. The speed of sailing vessels is an indeterminable quantity, in so far as it depends on the strength of the wind. For the same velocity of wind, the speed will vary with the amount of sails provided. This must, however, be largely governed by considerations of the size and stability of the vessel. All sailing ships are very much alike, and a certain amount of sail area is provided in proportion to their size, and they then sail with what speed they may attain. The form of the vessel has some influence on the speed, but here, again, the cargo-carrying necessity governs this element to a large extent. In most sailing vessels the full-bodied model which will carry a good dead-weight is more profitable than the sharper-formed one conducive

to a greater speed. The direction of the wind need not necessarily be the direction in which the ship moves. In fact, it is unusual for a vessel to encounter a steady stern wind, and a skilful navigator knows how to utilise a wind coming from any direction. A side wind is, as a rule, the one that suits him best. Figure **160** explains how it is that such a beam wind may make the vessel go ahead. The wind is represented by the arrows, and as it strikes the sails it is deflected, and a normal pressure, R, is the result. This pressure may be resolved into two forces, one, L, tending to move the vessel sideways, and another, F, tending to move it forward. The former causes but little motion, as it is difficult to move the long ship sideways through the water. F, on the other hand, will move the vessel forward with considerable speed, as there is comparatively little resistance to motion in this direction. Most fine and swift vessels will sail quicker with a beam wind than with a stern wind, chiefly because their sail arrangement admits of a larger area being utilised in the former instance. When the wind is right aft, the sails on the various masts more or less shelter those immediately in front of them.



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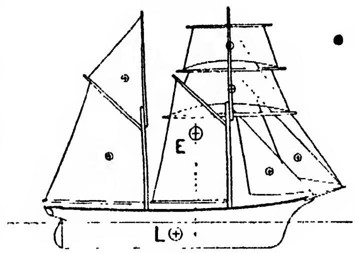
Wind Pressure on Sails. The side pressure of the wind on the sails is balanced by a corresponding pressure of the water on the opposite side of the vessel. The former acts as a force applied at the centre of gravity of the entire sail area, called the *centre of effort* [E, **161** and **162**], the latter as a similar force applied at the centre of gravity of the immersed longitudinal middle-line plane. This point [L, **161** and **162**] is called the *centre of lateral resistance*. These two forces, W and P [**162**] tend to heel the vessel until the righting moment of stability has become large enough to resist such action. The ship will then remain in this inclined position while being driven forward. The heeling moment will be equal to the resisting moment when the product of the total wind pressure, W, and the vertical distance between the centres of effort and lateral resistance is equal to the product of the displacement D and the horizontal distance between the centres of gravity, G, and buoyancy, B. A vessel with a lofty rig or with a large sail area will therefore require a greater amount of stability than one with low masts or with a small sail area. As a wind increases gradually from a calm, the speed of a vessel will increase, but when a certain force is reached, she will be heeled over to too great an angle, or the masts and rigging will be strained too much, and the sail area has to be reduced by reefing or by the removal of some of the individual sails, and this process will be going on as the force of the wind increases, until the vessel may be practically without sails. As the wind increases, so the effect of the waves, which tend to impede the progress of the vessel, will increase, with the result that the speed is very much reduced. It is, therefore, only within narrow limits that the speed of a ship is augmented with a higher wind velocity. The highest speed that sailing vessels attain for any length of time is 12 to 14 knots an hour with favourable winds.



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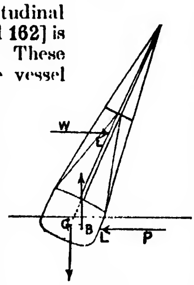

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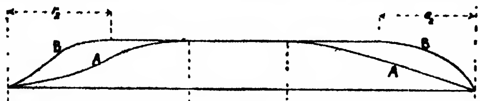
The Speed of Steamers. The speed of a steamer is a more definite quantity than that of a sailing vessel, as mechanical propulsive power of a given magnitude is provided. The earliest steamers were, however, provided simply with a set of engines, and they obtained such speed as they could, as it was then quite impossible to calculate the power required to propel a vessel through the water at a given velocity. As time went on, and experience was gained, it was possible to estimate fairly accurately from the results obtained with a certain vessel and a certain power what the speed would be for a similar vessel with a smaller or larger horse-power. At the present time an owner having a steamer built expects to get not only the speed and horse-power guaranteed, but also the amount of coal burnt per hour. The speed of an object being forced through the water will naturally depend, in the first instance, on the driving power, and, in the second instance, on the resistance the object offers to the motion. It is the marine engineer's business to provide the engine-power, and the naval architect has to design the ship so that the resistance to motion is a minimum. It might be imagined that as water is an easily divided fluid, it would offer but little resistance to the passage of a body through it, but the contrary is the case. The resistance of a ship is of two kinds. The sides and the bottom must, in the first instance, be rubbed against the water the vessel is moving past, much in the same way as an object being dragged along on land rubs against the ground, and thereby offers resistance to motion. This is called the *frictional resistance* of the ship. It will depend on the size and character of the outside surface of the ship, and on the speed. With rough bottoms covered with marine growths, the friction is very large, but with ordinary clean and well-painted bottoms, there is little variation in the frictional resistance. The amount of surface and the speed are, therefore, the chief elements to be considered. It is found that the resistance varies directly as the wetted surface of the vessel and directly as the square of the speed. Let F be the total resistance due to friction when the vessel is moving at a speed of S knots per hour, C the resistance of 1 sq. ft. of surface when moving at a speed of 1 knot per hour, and A the wetted surface of the vessel. The resistance due to friction is then:

$$F = C \times A \times S_2.$$

Wave-making Resistance. In passing through the water a ship causes a momentary channel to be made. At the bow the water is parted, and at the stern it again closes in upon the vessel. The result of this forcible parting is a piling up of the water or the creation of the familiar wave at the bow of every vessel going at a fair speed. The production of such a wave or series of waves requires a force of considerable magnitude, and it is, therefore, another element of resistance to the progress of the vessel. The amount of water piled up or the magnitude of the wave-making resistance depends largely on the size and form of the vessel and on the speed, but is independent of

the amount of wetted surface. This part of the resistance is a much more difficult one to deal with than the part due to friction. It is quite impossible to estimate mathematically what the wave-making resistance of a ship of given form will be. Generally speaking, it will, however, be augmented with an increase in the fulness of the form. Let 163 represent two water-lines of different ships. The degree



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of fineness may be measured by the lengths of entrance and run or the lengths of the wedge-shaped parts forward and aft respectively. The relative wave-making resistance of the vessels A and B will thus depend largely on the relative lengths of their entrances e and e_2, and of their runs r and r_2. B will thus have a much greater resistance than A. The length and draught of the vessel, as well as the form of the cross-sections, will also have some influence on the wave-making resistance. It was seen that the frictional resistance depended upon the square of the speed. The wave-making resistance increases, on the other hand, more rapidly with an increased speed. For moderate speeds up to about 12 knots per hour the resistance is thus chiefly due to friction, but when very high speeds are reached, the wave-making resistance becomes the most important. For each ship form there is usually a limit to the economical speed at which it can be driven. It would thus be very expensive to drive a very bluff-shaped vessel through the water at a very high rate of speed.

Experimental Tanks. The resistance of ships is now often estimated by experiments on models. When the resistance of one vessel is known, it is possible to estimate pretty accurately what the resistance of another of identical form but different dimensions will be. Some of the large shipyards have, therefore, long tanks, where they can determine the resistance of models by towing them through the waters at certain speeds. From the results thus obtained it is possible to estimate what the resistance of the full-sized ship would be. The models are made of paraffin wax to the exact form given by the drawings, hollowed out, and trimmed by small weights to float at the required draught. They are then fixed to a trolley travelling over the tank and towing the model, while the exact speed and resistance are being simultaneously and automatically recorded. Such experimental tanks are very valuable for the determination of the horse-power necessary to give a vessel the required speed, but they are very expensive to construct and to operate. It is, therefore, only few designers who have such means available to assist them in their estimates, and those who have not must resort to calculations based upon the results of existing vessels, with the particulars of which they are familiar.

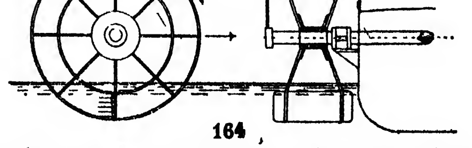
Approximate Methods of Determining Horse-power. It was seen that the frictional resistance varies as the square of the speed and, also, that it constitutes nearly the entire resistance of a ship at the lower velocities, and the greater part even at the somewhat higher speeds. As, moreover, the wave-making resistance also varies, more or less, as the square of the speed, the whole of the resistance may be assumed to vary as the square of the speed, S, of the vessel, particularly where the comparison is only applied to cases with small variations in the speed. Further, the frictional resistance varies as the amount of the vessel's wetted surface. For similar models the area of the surface will vary as the square of the linear dimensions, or as the two-third power of a cubical expression (say, the volume or weight of the displacement D). Comparing nearly similar ships, this expression $D^{\frac{2}{3}}$ may also be taken to be a rough measure of the wave-making resistance. The entire resistance may, therefore, be taken to be approximately represented by the product $D^{\frac{2}{3}} \times S^2$. When the resistance of a ship is known, the force to overcome it is known, and the required horse-power can be determined, as it will be the product of the resistance and the speed. If I.H.P. is the indicated horse-power and C a constant, then:

$$\text{I.H.P.} = C \times D^{\frac{2}{3}} \times S^3.$$

When the displacement, D, the speed, S, and indicated horse-power, I.H.P., are known, then C can be determined for that particular ship, and as long as the variations in size, form, and speed are not great, there will be little variation in the value of C. The horse-power required to drive a vessel of a slightly different displacement and slightly different speed is then determined by extracting the cube root of the number representing the tons of displacement, squaring the result, and multiplying it by the speed cubed and by the constant, C, as determined from the results of previous ships.

Effect of Size, Speed, and Propellers. The above expression for the horse-power shows the relative effect of the size and the speed of the vessel. For every per cent. increase in the size of the vessel as represented by the displacement, only $\frac{2}{3}$ of 1 per cent. increase in horse-power will be required to maintain the original speed, whereas for every 1 per cent increase in the speed of a vessel, the power will have to be increased 3 per cent., the displacement remaining the same. The enormous effect of the speed or the power required may also be seen from the fact that if the displacement is doubled it is only necessary to add about 60 per cent. to the horse-power to maintain the speed, but if the speed is doubled, 700 per cent. of an increase is required in the power, assuming the displacement to remain constant.

The horse-power determined by model tank experiments is that required to drive the vessel at the desired speed, and considerable addition must be made to this to obtain the number of indicated horse-powers it may be necessary for the engines and boilers to develop. The reason for this is that a great amount of power is lost between the pressure of the steam in the cylinders and the pressure of the propeller blades on the water. This



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waste of power is chiefly due to the friction of the machinery in the cylinders, bearings, thrust blocks, etc.; but a large amount of power is also lost in more or less inefficient churning of the water by the propeller. In many cases as much as double the amount of power required to overcome the resistance

of the vessel must be developed by the engines. It will thus be seen that model experiments do not solve the entire problem of determining the dimensions of engines necessary to give the desired speed. The horse-power given by the above approximate formula is usually that indicated by the engines; so that, although this method is rougher than the experimental one, it is more direct.

Paddle and Screw Propellers. A very important factor in the problem of propulsion is the propeller. The first type of these to be used and the simplest to understand is the paddle-wheel. As 164 shows, it consists of a wheel fitted with floats very much like those of a water-wheel. One wheel is fitted on each side of the vessel, and as they are being turned round by the engines, the floats will exert a pressure on the water they drive backwards. It is the return pressure of this water that sends the vessel ahead. The vessel will, however, not move forward a distance equal to the periphery of the wheel for each revolution, as in the case of a wheeled vehicle on land. The water will, to a certain extent, slip. The speed of the vessel will thus be the number of revolutions multiplied by the periphery of the wheel less a certain percentage called the *slip*, which will vary according to the design of both ship and propeller.

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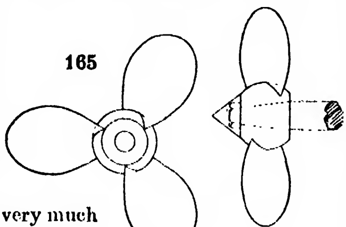
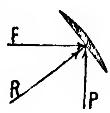
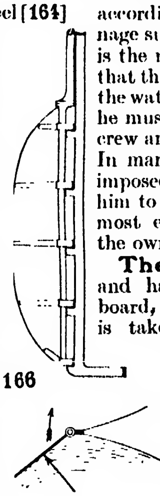




It will be observed that the floats of the wheel [164] strike the water rather obliquely at the first touch, and thus cause an unprofitable downward pressure in the water. To obviate this, all paddle-wheels are now constructed with feathering floats, which cant slightly, and are nearly vertical during the whole of their passage through the water. As already explained in an earlier article, paddle-wheels are now used only for river or channel vessels.

For all sea-going steamers, screw propellers are now invariably used, as they are of handier dimensions, and can be fitted deep down in the water, where they are not so likely to be damaged by being struck by waves. A ship's screw consists of a more or less spherical part, called the *boss*, which is hollow and fixed on to the shaft. On this boss there are two, three, or four warped blades very much like the wings of a windmill. Figure 165 shows a propeller with three blades. The after sides of these are parts of screw surfaces. The pitch of any screw is the distance it moves either forward or back during one complete turn. In the same way the pitch of a propeller is the distance it would travel for one revolution if it were moving in a solid. As water is not a solid, there is usually some slip with this form of propeller, as in the case of the paddle-wheel. The speed of the vessel will therefore again be the pitch of the screw multiplied by the number of revolutions, diminished by a greater or smaller percentage. To ensure a high degree of efficiency it is essential that the size, form, and pitch of the propeller should be properly adjusted to the revolutions and power of the engines.



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Steering. All vessels, whether propelled by sail or steam, are steered by a rudder, which has been of practically the same design through many centuries. It consists of a blade, which is straight on the fore edge, where it is hinged on to the sternpost and rounded on the free after edge, as shown by 166. It is free to be turned through an angle of some 30°. to 40°. on either side of the middle-line plane. When the rudder blade is thus turned to one side, as shown by the plan view [166], it will press on the water it comes in contact with as the vessel moves ahead. The stream of water which impinges on the blade causes, of course, an equal opposite pressure to be applied to the rudder, as indicated by the arrow, which has the effect of sending the stern of the vessel in the same direction, and thus tends to turn the ship. Rudder blades are now nearly always made of a single steel plate stiffened by either wrought iron or cast steel ribs or arms.

Difficulties of a Designer. A designer has to see that his ship is floatable, stable, strong, speedy, steerable, etc. He must provide the owner with a vessel that will carry a large amount of cargo on a small draught, and be propelled with a minimum of coal consumption; but in addition to all these primary and unavoidable difficulties, he has got to bear all the various Government regulations in mind, and design his ship so as to be as profitable as possible under the more or less arbitrary legal requirements of the country where she is to be owned. He has to arrange his structural details in such a way that the tonnage of the vessel is either large or small, according to whether the earning of a heavy tonnage subsidy or the payment of a small harbour due is the more profitable. He must further make sure that the vessel has the legal amount of volume above the water to act as safeguard against foundering, and he must provide sufficient life-saving appliances for crew and passengers in case the vessel does founder. In many other ways the designer is hampered by imposed regulations and conditions, and it is for him to effect such compromises as will result in the most efficient and all-round satisfactory ship to the owner.

The Trial Trip. When a steamer is built, and has got her engines, boilers, and outfit on board, and is in complete working order, she is taken on what is termed her *trial trip*. In large passenger vessels with a high guaranteed speed this is an important point in her completion; but if she is a cargo tramp it usually consists in her making a little pleasure trip with her builders and owners and their friends on board. During the trip the speed is, as a rule, tried by her steaming parallel to a measured mile marked by posts on the shore. From the time she takes to accomplish this distance her speed in knots is easily calculated. At the end of the trial trip the ship is formally handed over to her owners, and it remains for the experience of the next few years to show to what extent her designer has succeeded in producing a staunch and good vessel that will add to his fame and will earn a profit for the owners.

SHIPBUILDING *concluded; followed by* SHIP MANAGEMENT

continued from page 6059

THE PROCESSES OF BREWING

Malting. Hops and Yeast. Producing, Boiling, and Hopping the Wort. Gravity of Beers. Fermenting the Wort. Racking and Fining

THE importance of malt in brewing is amply recognised, and the brewer cannot take too great pains to obtain, or make, malt of the highest grade. Malt is the result of checking the natural process of germination of any cereal at a particular moment. In the brewery, barley provides the only first-class malt, and malt barley must form the principal ingredient in any mash. In some breweries a small proportion of prepared maize or rice or sugar is used. This substitution cannot be regarded as an adulteration but is rather employed to produce a particular type of beer.

In a few large breweries only is the malt actually made on the premises, most brewers purchasing their malt ready made from maltsters.

Malting. Malting may be divided into four stages: *steeping*, *couching*, *flooring*, and *kilning*, which follow one another in the order given.

The grain is shot into a cistern and covered to a depth of about 5 in. with water. All husks that float are skimmed off, for they are bad and would eventually contaminate the malt. The grain is kept under water for from 40 hours to 60 hours until it has swollen up and the process of germination been thereby started. If a corn when crushed between the finger and thumb breaks up into a flour or meal fairly readily, the steeping is complete. If a paste results, the grain is over steeped.

The next step is couching. The wet grain is removed from the steeping tanks and piled up in heaps called *couches*. There it remains for from 20 hours to 48 hours, the object being to enable it to generate sufficient heat to germinate evenly and well. Then the grain is spread out on the floors of the flooring-rooms and there germination progresses rapidly, the plumule growing up the back of the grain, and little rootlets being put forth. The maltster continually examines his grain, watching to see how far the acrospire or plumule has progressed. When it is between half way and three-quarters up the back of the grain, according to the fancy of the maltster, germination is stopped by the fourth process—namely, kilning. The malt is run on to the floors of the kilns, and there it is gradually heated, the operation commencing at about 90° F. When the moisture is nearly all driven off the temperature is gradually raised, the exact point reached being determined by the character of the malt desired.

Black and brown malts for black beer brewing are literally caramelised on the kilns, while pale malts are only heated to 185° F. During the process of kilning a good many of the rootlets come off and the remainder will be removed by the screening which the malt undergoes.

A First-class Malt. Undoubtedly experience is the great factor in malt buying, and only after long years can the brewer feel sure that his opinion is sound. In the first place the malt must be evenly grown. That is to say, that in a sample, the length to which the acrospire has grown must be about the same in every individual grain. In very few corns should the husk be pierced, and in very few cases should the growth not have reached half way up the back of the grain. The rootlets should be uniform in colour, and not be a mixture of colours. The total number of bad corns should not be above 3 per cent. and of these black sheep only a very few should be mouldy corns, for these would ruin the beer. The extract from the malt should exceed 90 lb. per quarter for best English malts.

Hops and Yeast. The third essential in brewing is the hop. The brewer buys hops in the open market, and on the judgment of his buyer a good deal of the success of the brewery depends. For the finest pale ales the new hops, mixed with a small proportion of the previous year's crop for the first few weeks of the season, should alone be used. For "dry hopping" also, the very best of the new hops should be used, and best Goldings and Worcesters are the classes recommended for this purpose by experts.

Yeast is a microscopic plant which grows very rapidly and, at the same time, converts the sugar in the beer into alcohol and carbonic acid. Under the microscope the plant should appear to consist of a number of round, well-nourished cells. The cells should be filled with a clear fluid, and should show no signs of granulation. Granulated cells are old ones which are dying. If there are many to be seen in a sample the yeast should be rejected. The micrographs (by the courtesy of the British Pure Yeast Co.) show ordinary Burton yeast [**5**] and yeast with elongated cells taken from beer in process of fermentation [**6**]. In Burton yeasts it is usual to find a number of oval cells, and as long as these seem fat and well-nourished the yeast is good. If, under the microscope, any rods are seen the yeast will decompose the beer, for those rods are bacilli giving rise to other forms of fermentation which are not wanted by the brewer. The age of the yeast is important, and it may be held that no yeast should be used for high-class brewing which is more than a week old.

Process of Brewing. We shall now make a trial brew to supplement the information which the reader will have gathered from the preceding pages. The first thing necessary is to warm the mash tun. This is done by running steam or hot water into it, and keeping the covers on. While the vessels are being heated the malt is weighed out, and after being carefully screened is passed through the grist mill.

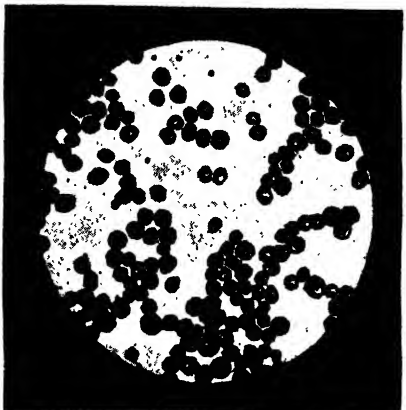
Now comes the question of the stiffness of the mash. The brewer's object is to get all the available extract out of the malt, and to do this it will generally be found that from two to two and a quarter barrels of water to each quarter of English malt weighing 336 lb. will give a good workable mash. More water makes the mash too thin, and less would make it so stiff as to greatly increase the difficulty of working.

Our malt is now ground and in the grist case, the mash-tun is warm, and everything is ready. Hot liquor, just under boiling point, is run into the tun, and the taps are opened. As soon as the temperature at the outfall pipes is the same as at the inlet, the taps are shut, and the calculated quantity of water to be used for the mash is run in.

The lids are put on, and the whole allowed to stand for about half an hour to thoroughly steam the interior of the tun. Then the covers are opened, and the liquor soon falls to the temperature at which mashing is to be effected, which should be between 140° F. and 152° F. for pale ales, and for black beers between 144° F. and 150° F.

Mashing and Sparging. The moment the liquor is ready the slides of the grist case are opened, and the grist run into the mash-tun as quickly as possible, while the rakes are set going at such a speed that they will revolve once in a minute. As soon as all the grist is in the covers are shut, and the rakes kept going for a quarter of an hour to ensure the mash being well mixed. The temperature of the mash is now taken, and after another fifteen minutes a small quantity of water at a higher temperature than the mashing heat is run into the tun through the underlet pipes at the bottom of the tun. This is to bring the total heat up a little. The rakes are now run three times round the tun, and then the mashing part of the process is completed.

The mash now stands in the tun for two hours, when "the taps are set," which means that the under taps are opened and the hot liquor, which now becomes *wort*, is run off to the under-back, where it must be kept at an even temperature, or is run straight to the copper. The spargers are now set going, and the brewer watches the heat of the sparging water very carefully, his object being to get all the extract out of the goods, but to get none of the soluble starch therefrom. Accordingly, he tries to make the sparging maintain the heat of the goods at about 156° to 158°, but never to permit it to rise to 160° nor to fall below 152°. The temperatures of sparge waters necessary to effect this vary according to the brewery and its construction, but it is as well always to sparge on a certain quantity of really hot water (say, about 170° to 175° first of all), to restore the heat to the upper strata of the goods which have got cooled during the two hours mashing. Then, when the temperature begins to rise, the heat of the sparges must be lowered gradually, or the goods will get heated above 160°, and the wort will contain free starch.



5. PHOTO-MICROGRAPH OF BURTON YEAST

Difficulties in Mashing and Sparging. Taken all round, about four hours' sparging will secure the proper cleansing of the goods, if the apparatus is all that can be desired, and the sparges should be graduated carefully, much less being run off in the first hour than in those succeeding. Mr. Southby advises that in the first hour three-quarters of a barrel per quarter of malt used is ample to run off, and twice that should be run off in the last hour.

There are two great sources of annoyance to the brewer at this stage of work. The first is called *flooding of the goods*, which always brings about imperfect drainage of the wort, and the second is the production of a cloudy wort. Excessive stirring will cause flooded goods, and the remedy is obvious. If, however, it is found that less stirring in that particular tun tends to the formation of balls in the goods, then the plant is defective, and either rakes with an increased speed must be fitted, or an outside masher added to the brewery. Flooded goods may result from the presence of an excess of floury matter in the grist. To obviate this, the malt must not be ground so finely in the grist mill, and where pure malt only is used this always cures the trouble.

Cloudiness of the wort may be caused by particles of the goods being forced through the false bottom of the tun. When this is the case on the first setting of the taps, and if, later, the wort runs clear, the cloud is of little importance, for the cloudy wort can be returned to the top of the goods, and the clear wort run off to the under-back. If the cloudiness continues, the plant, again, is defective, and will have to be seen to. A cloudiness which sometimes makes its appearance at this stage of brewing, and is much more serious, may be due to the use of unsound malt, or may be brought about by heating the mash too much. In either of these cases the wort is practically useless.

Boiling and Hopping. The brewer has now obtained his wort by the recognised English method of infusion, and it has either been run direct to a steam-heated copper, or has been collected in the under-back.

The wort at this stage is liable to undergo change, and the general principle is to try and get it all into the coppers as quickly as possible. The change, however, is sometimes advisable, especially when the malts are deficient in diastatic power, and then the brewer allows his wort to "stew" a little at a temperature of 150° to 165°. This can be effected either in the under-back or in the copper. As soon as the wort reaches 165° it must be raised to the boiling point as quickly as possible to stop any further stewing. While the wort is boiling in the copper the hops are added, the practice in different breweries varying. Some add all the hops at once; others add only a portion, and keep a quantity of the finest hops to be added just before the contents of the copper are turned out. This last method preserves the aroma of the hop very well.

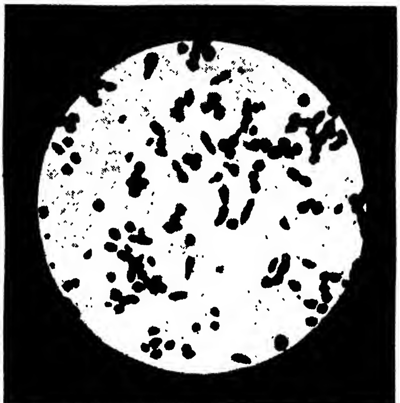
At whatever period of the boiling the hops are added, they must be well pressed down into the seething wort so as to ensure that they are all well wetted. Any hops that float dry on the surface lose their aroma in the steam and do not benefit the wort. For at least an hour, and preferably for two to two and a half hours, the wort is kept in active ebullition, second wort requiring a little longer than first wort where the coppering is done in two stages. Then the contents of the copper are run as quickly as possible into the hop back. For a quarter of an hour the wort stands in the hop-back to allow the sediment to settle, and then it is run off bright to the coolers, the hops remaining behind.

Cooling and Refrigerating. Besides reducing the temperature of the wort to the right point for fermentation to take place, the coolers and refrigerators [4] are essential to complete the aeration of the wort. Whatever forms of these are used, the wort must be reduced to 60° F. in less than six hours from the time it leaves the copper, or else dangerous changes may take place in the wort, and bad beer result. From the coolers

the wort runs either to the fermenting vats at once, or is drawn off into the collecting vessel, there to await the advent of the Excise officers, who at this stage come to determine how much duty has to be paid by the brewer on the beer he is now about to make.

Specific Gravity of Beer. There are two methods of calculating the value of any particular beer. One states the beer in terms of pounds per barrel, and is based on the following facts. It is known that a barrel of pure water weighs 360 lb. avoirdupois, and consists of 36 gallons. Now take a barrel of water, remove one gallon, and the weight will be 350 lb. Fill up the vacant space with a gallon of sugar solution weighing 16 lb., and the total weight of the full barrel will be 366 lb. This, being 6 lb. in excess of the normal weight of a barrel, would be spoken of as a liquor of 6 lb. gravity. This strength is determined by means of a saccharometer, an instrument which is immersed in the beer or wort, and sinks more or less according to the gravity of the fluid. The point to which the instrument sinks is read off and that gives at once the gravity of the beer in pounds.

This is not the method adopted by the Excise officers. They use a more accurate instrument, known as *Bates' Saccharometer*, which is really a modified hydrometer adjusted for beers and worts. It is graduated on the basis of distilled water being of the specific gravity 1·000 at normal temperature. The reading is taken as well as the temperature of the liquid. If the temperature is above or below 60° F., the operator refers to the tables provided and makes the correction necessary. The depth of the fluid in the main collecting vessel or tun is taken, and the area of the floor of the vessel is known, so a simple calculation will tell at once how many barrels of wort or of beer are in the tun.



6. GROWING YEAST CELLS IN FERMENTING BEER

The Customs make this experiment before fermentation takes place, and they have adopted a gravity of 1·055 as a standard, charging the brewer 7s. 9d. for each 36 gallons of beer or stout at that gravity which could be made from the wort present, after making an allowance of 6 per cent. for wastage during later stages.

Fermentation. The temperature at which the process is started depends on the original gravity of the wort. For strong beers 58° is a good heat, for ordinaries 60° is the best, while for beers which are expected to be consumed immediately, as high a temperature as 63° may be used.

As the wort is run into the tuns the yeast is mixed with it, the process being known as *pitching*. The amount of yeast again depends on the strength of the worts, the quality of the water, and the amount of hops used, but varies from 1 lb. per barrel for mild ales to 4 lb. for very strong stingoes.

When the wort, mixed with yeast, is all in the tuns, fermentation commences. Gradually a white foam rises to the top, and as the process continues this foam grows into mountains of froth, which eventually break down into an ordinary, thick, creamy yeast head, which tells the brewer that fermentation is nearly at an end. But he does not depend on his eye to know when to stop fermentation, or *cleanse* the beer, as it is called. At least three times a day while fermentation is going on samples are drawn from the tun and tested with the saccharometer. At the end of the first day it will be found that the gravity of the beer goes down about 1 lb. every three or four hours, while the temperature in the tun rises 1° or 2° in the same period. If this speed is not attained, then the beer must be roused, or stirred up, or warm water run through the attemperators. On the other hand, if the beer is getting on too fast, the temperature may be reduced by running cold water through the attemperators.

Cleansing and Racking. When the beer has reached the gravity which the brewer desires, he cleanses the beer of yeast either by skimming all the yeast off the top of the tun and returning it to the yeast backs, or he runs the beer and yeast into large barrels and lets the yeast work out of the bungholes, care being taken to keep the vessels perfectly full. This is the process used at Burton. When the beer is cleansed it is run into the racking squares and allowed to settle for a short time, so as to permit the yeast in the beer itself to settle, for yeast in the cask may cause trouble later on. This part of the process often takes place in the fermenting vat.

For first-class ales, and for export ales, and even for the best Dublin stouts, brewers often have recourse to "dry hopping"—that is to say, that a certain quantity of the very finest new hops is introduced into each barrel through the bunghole before the beer is run in from the racking squares and the casks closed with shives. For beers which are to stand for long, porous spiles must be fitted at first or else the head of the cask may be blown out.

Fining. Fining beers is often done in the brewery just before the trade casks are sent out; but frequently the publican fines his own ales. The finings are made of isinglass, and are either white or brown. They are generally prepared by working up about 4 lb. of isinglass in about a hogshead of weak acid or sour beer; of either class of finings from one pint to two pints to the barrel will suffice unless the beer be very stubborn indeed. The brewer must discover by experiment what is the smallest quantity of finings that will render his ales bright, and must not exceed that.

The prospective brewer should attend a good brewery as a pupil for some time so that his eye may get trained to perceive the tiny indications which tell him that all is going well. If he wish to enter into the chemistry of the art he will find the "Laboratory Text Book for Brewers," by Lawrence Briant, an excellent elementary work, and for the variations in the processes of brewing, as well as for the higher science of his calling, the "Handbook of Practical Brewing," by E. R. Southby, published by the "Brewing Trade Review," of Little Trinity Lane, E.C., a most useful work. To enable the brewer to keep abreast of the times, the "Brewing Trade Review" is one of several useful papers.

BREWING *concluded; followed by* WINES AND CIDERS.

TRIGONOMETRICAL RATIOS

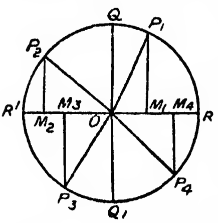
Definitions of the Ratios. Relations Between Ratios of the Same Angle. Changes in Magnitude of the Ratios

continued from page 6086

By HERBERT J. ALLPORT, M.A.

8. The Trigonometrical Ratios. Suppose an angle of any magnitude A [see note, Art. 4] to be traced by the revolution of OP from the initial position OR. Draw QOQ′ at right angles to ROR′. Unless the angle A is an exact number of right angles, the revolving line must take up some position in one of the four *quadrants* ROQ, QOR′, R′OQ′, Q′OR. In the figure, four different values of A are shown, corresponding to the four positions P_1, P_2, P_3, P_4 of P.

Draw PM ⊥ to OR. Then OM is the projection of OP on the initial line, and MP is equal to the projection of OP on OQ (which makes + 90° with the initial line). From the three quantities, OP and its projections, we can form *six* ratios. These ratios are of great importance in treating of the angle A, and each has a separate name.



(1) The ratio of MP to OP is called the *sine* of the angle A.

(2) The ratio of OM to OP is called the *cosine* of the angle A.

(3) The ratio of MP to OM is called the *tangent* of the angle A.

The remaining three ratios are formed by inverting the first three Thus,

(4) The ratio of OP to MP is called the *cosecant* of the angle A.

(5) The ratio of OP to OM is called the *secant* of the angle A.

(6) The ratio of OM to MP is called the *cotangent* of the angle A.

The *order of the letters* in the above ratios must be carefully noted, since OM and MP stand for the projections of OP on OR and OQ respectively, and *these projections vary in sign according to the quadrant in which* OP *lies*. For example, if A is an angle lying between + 5 right angles and + 6 right angles, the revolving line will be in the second quadrant, such as OP_2, and its projection OM_2 is then *negative* [Art. 7]. The cosine of the angle A is then $\frac{OM}{OP}$, *i.e.*, a *negative* quantity, by the algebraic rule of signs.

The six ratios thus defined are called the trigonometrical ratios of the angle A. They depend only on the magnitude of A, and not on the length of OP. For if OP were taken of a different length, the new triangle, OPM, would be similar to the old one, and therefore (*Prop.* 56) the ratios of the sides would be the same as before.

9. Instead of "sine of the angle A," etc, we speak of sine A, cosine A, and so on; while, in writing them, we abbreviate them into sin A, cos A, tan A, cosec A, sec A, and cot A respectively.

10. From the above we see that to obtain the ratios of any given angle we take any point in either of the arms containing the angle, and draw a perpendicular from that point to the other arm, produced if necessary. The beginner will do well always to try and imagine that the arm to which he draws the perpendicular is in the position OR of the figure to Art. **8**; he will then have no difficulty in seeing in which quadrant the other arm must lie, and, consequently, whether OM and MP are positive or negative.

11. Note that the ratios of an angle are mere *numbers*, or *fractions*. We may therefore have any *power* of a ratio. For example, the third power of sin A would be $(\sin A)^3$. This is always, for convenience, written $\sin^3 A$. Again, such an expression as cos A . tan B means the *product* of the cosine of angle A and the tangent of angle B.

12. Relations between the Ratios of the same Angle. From the definitions of Art. **8** it is evident that

(1) $\sin A = \frac{1}{\operatorname{cosec} A}$.

Similarly,

(2) $\cos A = \frac{1}{\sec A}$,

and

(3) $\tan A = \frac{1}{\cot A}$.

Also,

(4) $\tan A = \frac{MP}{OM} = \frac{\frac{MP}{OP}}{\frac{OM}{OP}} = \frac{\sin A}{\cos A}$;

and, therefore,

$$\cot A = \frac{\cos A}{\sin A}.$$

By referring to the figure of Art. **8** we have, from *Prop.* 34,

$$OM^2 + MP^2 = OP^2.$$

Hence, $\frac{OM^2}{OP^2} + \frac{MP^2}{OP^2} = 1$;

or, $\cos^2 A + \sin^2 A = 1.$

Dividing both sides of this equation by $\cos^2 A$, and using (2) and (4) we get

$$1 + \tan^2 A = \sec^2 A.$$

Similarly, dividing by $\sin^2 A$, we get

$$\cot^2 A + 1 = \operatorname{cosec}^2 A.$$

13. The five results just proved must be committed to memory—namely,

(1) $\sin A = \dfrac{1}{\operatorname{cosec} A}$.

(2) $\cos A = \dfrac{1}{\sec A}$.

(3) $\tan A = \dfrac{1}{\cot A}$.

(4) $\tan A = \dfrac{\sin A}{\cos A}$

$\cot A = \dfrac{\cos A}{\sin A}$.

(5) $\sin^2 A + \cos^2 A = 1$

$1 + \tan^2 A = \sec^2 A$

$1 + \cot^2 A = \operatorname{cosec}^2 A$.

It is generally convenient, in proving an identity, to express the other ratios in terms of the sine and cosine, by means of these relations.

EXAMPLE. Prove that

$$\frac{\cot A + \tan B}{\tan A + \cot B} = \cot A \,.\, \tan B.$$

The expression on the left

$$= \frac{\dfrac{\cos A}{\sin A} + \dfrac{\sin B}{\cos B}}{\dfrac{\sin A}{\cos A} + \dfrac{\cos B}{\sin B}} = \frac{\dfrac{\cos A \cos B + \sin A \sin B}{\sin A \cos B}}{\dfrac{\sin A \sin B + \cos A \cos B}{\cos A \sin B}}$$

$$= \frac{\cos A \sin B}{\sin A \cos B} = \frac{\cos A}{\sin A} \times \frac{\sin B}{\cos B} = \cot A \,.\, \tan B.$$

The working of such examples should cause no difficulty if the five formulæ are well known, and if it is remembered that sin A, etc., are *numbers—i.e.*, that the example is simple *arithmetic*.

14. The five relations between the six trigonometrical ratios proved in Art. **12** enable us to express any five of the ratios in terms of the sixth.

EXAMPLE. Express the other trigonometrical ratios in terms of the tangent.

From (5) we have

$$\sec A = \sqrt{1 + \tan^2 A}$$

$$\therefore \cos A = \frac{1}{\sqrt{1 + \tan^2 A}}.$$

Hence,

$$\sin A = \sqrt{1 - \cos^2 A}$$

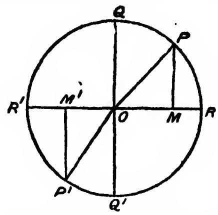
$$= \sqrt{1 - \frac{1}{1 + \tan^2 A}} = \frac{\tan A}{\sqrt{1 + \tan^2 A}};$$

$$\therefore \operatorname{cosec} A = \frac{1}{\sin A} = \frac{\sqrt{1 + \tan^2 A}}{\tan A}.$$

Also, from (3) $\cot A = \dfrac{1}{\tan A}$, so that the other five ratios are now expressed in terms of tan A.

15. Changes in the Magnitude of sin A. As A increases from 0° to 360° the magnitude of sin A changes. Let OR be the initial line, and let OP trace out the angle A. Suppose ROP is one value of A. Draw PM $\perp$ to OR. Then $\sin A = \dfrac{MP}{OP}$.

Now, when A = 0°, OP coincides with OR, so that MP is zero. Thus, when A is 0°, sin A is 0. Again, when A = 90°, OP and MP both coincide with OQ, which is equal to OR. Hence, when A is 90°, sin A $= \dfrac{OQ}{OQ} = 1$. Also, as A *continuously* increases from 0° to 90°, *i.e.*, passes through *every* possible value between 0° and 90°, the length of MP continuously increases from zero to OP; so that $\dfrac{MP}{OP}$, *i.e.*, sin A, continuously increases from 0 to 1.



In exactly the same way we see that as A continuously increases from 90° to 180°, sin A continuously decreases from 1 to 0.

Next, as A increases between 180° and 270°, the revolving line passes through such positions as OP'. Evidently M'P' is now negative, and since OP is always positive we have $\dfrac{M'P'}{OP'}$ negative; *i.e.*, as A increases continuously between 180° and 270°, sin A continuously decreases from 0 to −1.

Similarly, as A continuously increases from 270° to 360°, sin A continuously increases from −1 to 0.

Hence, *the sine of an angle can never be greater than + 1 and never less than − 1.*

16. Changes in the Value of cos A. The student can now verify for himself that as A increases from 0° to 90°, cos A decreases from 1 to 0. As A increases from 90° to 180°, cos A decreases from 0 to − 1. As A increases from 180° to 270° cos A increases from − 1 to 0. As A increases from 270° to 360° cos A increases from 0 to 1.

Hence, *the cosine of an angle can never be greater than + 1 and never less than − 1.*

17. Changes in the Value of tan A. Referring to the figure of Art. **15**, when A is 0°, MP is zero, and OM is equal to OP. Therefore tan A, or $\dfrac{MP}{OM}$ is zero. As A increases between 0° and 90°, MP continuously increases, while OM continuously decreases, hence, $\dfrac{MP}{OM}$ continuously increases. When A approaches 90°, OM becomes infinitely small, until, when A is 90°, $\dfrac{MP}{OM}$ becomes OP divided by an infinitely small quantity, *i.e.*, tan A is an infinitely great quantity. Thus, between 0° and 90°, tan A increases continuously from 0 to ∞.

Similarly, between 90° and 180°, tan A decreases from ∞ to 0. Between 180 and 270°, tan A decreases from 0 to $-\infty$. Between 270° and 360° tan A increases from $-\infty$ to 0.

Continued

Continued from page 6096

ITALIAN

Continued from page 5947

By Francesco de Feo

IRREGULAR VERBS

Third Conjugation—continued

Past Definite in **si**

Aprire, to open

Ind. Pres.—Apro, apri, apre, etc.

Past Def.—Aprii (apersi), aprì (aperse), aprìrono (apèrsero).

Past Part.—Aperto.

Assalire, to assault

Ind. Pres.—Assalgo, assalisci and *assali, assale, assaliamo, assalite, assalìscono* and *assàlgono.*

Past Def.—Assalii (assalsi), assalì (assalse), assalìrono (assàlsero).

Subj. Pres.—Assalisca and *assalga*; third person plural, *assalìscano* and *assàlgano.*

Past Part.—Assalito.

Benedire, to bless

Ind. Pres.—Benedico, benedici, etc.

Imperf.—Benedicevo and *benedivo,* etc.

Past Def.—Benedissi, benedicesti, benedisse, benedicemmo, benediceste, benedissero; and *benedii, benedisti, benedì, benedimmo, benediste, benedirono.*

Subj. Pres.—Benedica, etc.

Past Part.—Benedetto.

Gerund—Benedicendo.

Coprire, to cover

Past Part.—Coperto [see *aprire*].

Costruire, to construct

Ind. Pres.—Costruisco, etc.

Past Def.—Costruii, etc. (regular) (*costrussi, costrusse, costrùssero*).

Past Part.—Costruito (*costrutto*).

Dire (Dicere), to say, to tell

Ind. Pres.—Dico, dici, dice, diciamo, dite, dìcono.

Imperf.—Dicevo, dicevi, diceva, dicevamo, dicevate, dicèvano.

Past Def.—Dissi, dicesti, disse, dicemmo, diceste, dìssero.

Future—Dirò, dirai, dirà, etc.

Imperat.—Di', dica, diciamo, dite, dìcano.

Subj. Pres.—Dica, dica, dica, diciamo, diciate, dìcano.

Imperf.—Dicessi, dicessi, dicesse, dicèssimo, diceste, dicèssero.

Condit.—Direi, diresti, direbbe, etc.

Past Part.—Detto.

Pres. Part.—(Dicente).

Gerund—Dicendo.

Istruire, to instruct [see *costruire*].

Maledire, to curse [see *benedire* and *dire*].

Offrire (Offerire), to offer

Ind. Pres.—Offro, offri, etc.; (*offerisco, offerisci,* etc.).

Past Def.—Offrii, offristi, etc.; (*offersi, offerse, offèrsero*).

Past Part.—Offerto.

Profferire, to offer

Past Part.—Profferito and *profferto* [see *offerire*].

Salire, to ascend, to go up

Ind. Pres.—Salgo, sali, sale, saliamo, salite, sàlgono (salisco, salisci, etc.).

Past Def.—Salii, salisti, salì, etc. (*salsi, salse, sàlsero*).

Subj. Pres.—Salga, salga, salga, saliamo, saliate, sàlgano.

Imperat.—Sali, salga, saliamo, salite, sàlgano.

Past Part.—Salito.

Scolpire, to engrave

Ind. Pres.—Scolpisco, etc.

Past Def.—Scolpii, scolpisti, etc. (*sculsi, sculse, scùlsero*).

Past Part.—Scolpito (*sculto, scólto*).

Soffrire, to suffer [see *offrire*].

Exercise LV.

1. Intesi picchiare, aprii, ma non vidi nessuno. 2. "Che Iddio vi benedica," disse la pòvera madre. 3. Quando il signor N. ritornerà in ufficio, gli dirò che siete venuto. 4. Se mi aveste detto la verità, vi avrei perdonato. 5. Gli offrimmo cinquecento lire, ma non volle accettare. 6. Se non le dispiace di salire fino al quarto piano (floor), le mostrerò il violino di cui le parlai l'altro giorno. 7. Di' a tuo cugino che venga domani da me, perchè ho da parlargli. 8. Voi non potete crèdere quanto àbbia sofferto quell' infelice! 9. Questo ponte fu costruito quattrocento anni fa (ago).

Esercizio di Lettura—continued

Don Rodrigo era fin allora rimasto tra la ràbbia e la maravìglia, attònito, non trovando parole; ma, quando sentì intonare una predizione, s'aggiunse alla ràbbia un lontano e misterioso spavento.

Afferrò rapidamente per ària quella mano minacciosa, e, alzando la voce, per troncàr quella dell' infàusto profeta, gridò: "èscimi di tra' piedi[1], villano temeràrio, poltrone incappucciato[2]."

Queste parole così chiare acquietàrono in un momento il padre Cristòforo. All' idea di strapazzo e di villanìa era, nella sua mente, così bene, e da tanto tempo, associata l'idea di sofferenza e di silènzio, che, a quel complimento, gli cadde ogni spìrito d'ira e d'entusiasmo, e non gli restò altra risoluzione che quella d' udir tranquillamente ciò che a don Rodrigo piacesse d' aggiùngere. Onde, ritirata placidamente la mano dagli artigli del gentiluomo, abbassò il capo, e rimase immòbile, come, al cadèr del vento, nel forte della burrasca, un àlbero agitato ricompone naturalmente i suoi rami, e riceve la gràndine come il ciel la manda.

"Villano rincivilito[3]!" proseguì don Rodrigo, "tu tratti da par tuo[4]. Ma ringràzia il sàio[5] che ti copre codeste spalle[6] di mascalzone[7], e ti salva dalle carezze che si fanno ai tuoi pari, per insegnàr loro a parlare. Esci con le tue gambe, per questa volta[8] e la vedremo."

Così dicendo, additò[9], con impero sprezzante, un ùscio[10] in fàccia a quello per cui èrano entrati; il padre Cristòforo chinò il capo, e se n' andò[11], lasciando don Rodrigo a misurare, a passi infuriati, il campo di battàglia.

NOTES. 1. get out of my way; 2. you dolt of a friar; 3. tamed boor; 4. you are acting your natural part; 5. habit; 6. your shoulders; 7. scoundrel; 8. you may go away on your own legs this time; 9. pointed; 10. door; 11. went away.

PROPOSITIONS

Subjective Propositions. Subjective propositions are generally constructed with the conjunction *che*, and the verb may either be in the indicative or the subjunctive mood. Examples:

Delle volte avviene che gli uòmini più pacìfici pròvocano (or *pròvochino*) *discòrdie*, It happens sometimes that the most peaceful men provoke dissensions; *È chiaro che avete* (or *abbiate*) *ragione voi*, It is clear that you are right.

But it is a rule to use the subjunctive:

1. In dependence upon verbs indicating a sentiment or an opinion, as: *Mi dispiace*, I am sorry; *Mi duole*, I regret; *Mi pare*, It seems to me; *È meglio*, It is better, etc. Examples: *Mi pare che non ci sia niente altro da fare*, It seems to me that there is nothing else to do; *È meglio che abbiate parlato così*, It is better that you have spoken so; *Mi dispiace che abbiate dovuto aspettare*, I am sorry that you have been obliged to wait.

2. In dependence upon a negative proposition, or a proposition having a negative meaning, as: *Non è vero che io t'àbbia detto questo*, It is not true that I have told you this; *Raramente avviene che il delitto resti impunito*, It seldom happens that crime remains unpunished.

3. When a fact is represented, not as real or present, but only as possible or future, as: *Bisogna che ognuno lavori*, It is necessary that everyone should work; *È giusto che gli scolari diligenti sìano premiati*, It is just that diligent pupils should be rewarded.

Subjective propositions may also be constructed with the infinitive, as: *Molto spesso accade di restare* (*che si resti*) *disillusi*, It very often happens that one is disappointed; *È vietato fumare* (*che si fumi*), Smoking is prohibited; *È necessàrio pensare* (*che si pensi*) *all'avvenire*, It is necessary to think of the future.

Objective Propositions. Objective propositions, like the subjective, are constructed with the conjunction *che*. We use the indicative when a fact is mentioned with certitude or conviction, as:

Sono convinto che la cosa è così, I am convinced that the thing is so; *Dico che il tutto è uguale alla somma delle sue parti*, I say that the whole is equal to the sum of its parts.

But when a fact is mentioned as only possible—*i.e.*, as an opinion, a doubt, a wish, etc.—the subjunctive or the future of the indicative must be used. Examples: *Spero che suo padre sia completamente guarito*, I hope that your father is completely cured; *Mi àuguro che tutto vada* (or *andrà*) *bene*, I wish that everthing may go well; *Credo che questa volta àbbia detto il vero*, I think that this time he has spoken the truth; *Credo che pioverà*, I think it will rain.

The subjunctive must also be used when an objective proposition depends upon a negative or interrogative proposition, as: *Non son sicuro che egli esegua i miei òrdini*, I am not sure that he executes my orders; *Chi crederebbe che vi fòssero al mondo delle persone sìmili?* Who would believe that there are such persons in the world? *Io non credo che gli abbiate parlato*, I do not believe that you have spoken to him.

NOTE. After the verbs *temère*, to fear; *sospettare*, to suspect; *badare*, to take care; *dubitare*, to doubt, it was a rule to use the conjunction *che* followed by *non* (*che non*), but modern usage prefers to omit the *non*, in order to avoid ambiguity. Examples: *Dùbito che egli* (*non*) *arrivi in tempo*, I doubt about his arriving in time; *Sospettammo che* (*non*) *ci volessero ingannare*, We suspected that they wished to cheat us.

But it is common to use *che non* in the expressions: *Poco mancò che non restassi bruciato*, I came within very little of being burned; *Poco mancò che non mi tagliassi un dito*, I very nearly cut my finger.

Objective propositions are also constructed with the infinitive preceded by the preposition *di*, as: *Vi prego di continuare*, I beg you to continue; *Ho paura di prender freddo*, I am afraid of catching cold.

NOTE. After the verbs *volère*, *potère*, *sapère*, *dovère*, *fare*, *lasciare*, *vedère*, *udire*, *sentire*, the infinitive is used without preposition, as: *Voglio dire tutto quello che so*, I wish to say all I know; *Non so parlare tedesco*, I cannot speak German; *Fècero arrestare il ladro*, They had the thief arrested.

After some verbs, as *tornare*, *cominciare*, *aiutare*, *mèttersi*, *aspirare*, etc, the objective infinitive is governed by the preposition *a*, as: *Torna a scrivere*, He resumes writing; *Aiutàtemi a portare questo tàvolo*, Help me to carry this table; *Comìncio a capir meglio*, I begin to understand better; *Li invitammo a passare una settimana con noi*, We invited them to spend a week with us.

When the object is expressed by a noun or pronoun it is often repeated by a pronominal particle, which gives more strength to the expression, as:

Questo lo so, I know this; *Lo sbàglio l'ho fatto io*, I have made the mistake; *La farò io la giustizia*, I will do justice.

The partitive object preceding the verb is repeated by *ne*, as: *Danari non te ne posso dare*, I cannot give you any money; *Di codesti consigli io non ne ho bisogno*, I have no need of these counsels of yours.

Note here the meaning of the following expressions, in which *la* is used as an indefinite object: *Egli se la gode*, He passes his life in enjoying himself; *Se l'è svignata*, He has succeeded in getting out of it; *Non la vuo'e intèndere*, He does not want to understand the reason; *Chi la dura, la vince*, Perseverance always gains its end; *Me la pagherà*, He shall pay for the trick he has played me.

The verbs *èssere* and *stare*, followed by the infinitive preceded by the preposition *per*, indicate a near future, as: *Egli sta per morire*, He is at the point of death; *Egli è per uscire*, He is on the point of going out; *Sta per venire*, He is just now coming.

CONVERSAZIONE

Il suo amico ha parlato con l'avvocato?

Lui dice di sì, ma io non credo che gli àbbia parlato.

Se è così, gli scriverò io direttamente.

Bisogna che gli scriva sùbito, perchè la causa è fissata per giovedì pròssimo.

Quanto crede che gli debba offrire?

Non saprei (I do not know), tutto dipende dall'importanza dell'affare.

Si tratta di ben poco, ma quando si ha da fare con gli avvocati non si sa mai dove si va a finire.

Questo è vero; e se vuole un consiglio da amico, cerchi di venire a un accordo.

KEY TO EXERCISE LIV.

1. They appeared dressed in so strange a manner that we all began to laugh. 2. We have bought a new sewing-machine. 3. The impression that he received from seeing the man who had died for him, and the man killed by him, was new and unspeakable. 4. Give me something to eat, because I am dying of hunger. 5. Your servant must be a good man; I have always heard him praised by everyone. 6. I have not succeeded in understanding a word of what he has said. 7. If it does not rain we will go out too. 8. I never heard such a thing! 9. The buttons of my shirts have all come off; I beg you to sew them better next time. 10. I cannot understand why he has not yet come.

Continued

SPANISH

Continued from page 6092

By Amalia de Alberti & H. S. Duncan

Commercial Letters—continued

London.

Messrs. ———
Malaga.

Dear Sirs,

I am in receipt of your esteemed favour of ——, and of the samples of iron ore which you were good enough to send me.

I have taken good note of what you say, and am quite prepared to be of service to you on the recommendation of our mutual friends Messrs. A.B.C., of Seville.

I have had the samples of iron ore analysed, and, as you will see from the enclosed certificate of analysis, the result is the same as that obtained on your side. It is good mineral, and of a kind well suited to the requirements of the Welsh ironfounders.

The cost of the analysis is £1 1s., which I have debited to your account. I readily accept the conditions you mention for the sale of the consignments of ore, and, as I am in constant touch with the principal founders of this country, as soon as you advise me that you are in a position to make consignments, I will attend to the necessary contracts and chartering.

Awaiting your reply,
I remain,
Yours faithfully,
JOHN BROWN.

Londres.

Sres ———
Malaga.

Muy Sres mios,

He tenido el gusto de recibir su apb^le^ del —— asi como tambien las muestras de mineral de hierro que han tenido Vds á bien mandarme.

Enterado de cuanto se sirven Vds decirme estoy pronto à servir à Vds dada la recomendacion que se nos ha hecho de esa respetable casa por los mutuos amigos los Sres A.B.C., de Sevilla.

He hecho analizar las muestras del mineral de hierro cuyo resultado como verán Vds por el certificado de analisis adjunto, concuerda con el practicado en esa. Es un mineral bueno y su clase muy á proposita para estos fundidores de Gales.

El costo del analisis asciende á £1 1s. que le dejo cargado en cuenta. Son conformes las condiciones que Vd señala para la venta de cargamentos de su mineral y como estoy en continuo contacto con los principales fundidores de este pais, tan pronto me avise Vd que está en disposicion de hacer embarques, me ocuparé de efectuar los contratos y fletamentos necesarios.

En la espera de sus noticias, tengo el gusto de ofrecerme de Vds ato. S.S. q.s.m.b.

JOHN BROWN.

Barcelona.

Don John Brown,
London.

Dear Sir,

We enclose a letter of introduction from our friends Messrs. T. P. & Co., of this city, with whom we have had friendly business relations for many years. Our object in writing to you under the auspices of our said friends is to ask if you would be willing to open a credit for our account to the extent of £5,000 for bills at 60 days in favour of Messrs. A. T. & Co., of New Orleans, for consignments of cotton sent to us here.

If you are willing, as we hope you will be, to undertake this transaction, will you kindly let us know your conditions.

We have the pleasure to remain,
Yours faithfully,

Barcelona.

Don John Brown,
Londres.

Muy Señor ntro,

Acompañamos una carta de presentacion de nuestros amigos los Sres T. P. y Cia de esta plaza con quienes nos unen buenas relaciones comerciales y amistosas desde hace muchos años. Nuestro objeto al dirigirnos hoy á Vd bajo los auspicios de dichos amigos es para suplicarle tenga à bien decirnos si estaria Vd dispuesto á abrirnos un crèdito hasta la suma de £5,000 y á favor de los Sres A. T. y Cia de Nueva Orleans, mediante giros á 60 dias vista, contra embarques de algodon à esta, à nuestra consignacion.

Si como esperamos, esta Vd dispuesto à admitir esta operacion, le agradecerémos se sirva decirnos que condiciones habrian de regir.

Con este motivo nos es grato suscribirnos de Vd. atcs S.S. q.s.m.b.

London.

Messrs. ———,
Barcelona.

Gentlemen,

I beg to acknowledge receipt of your esteemed favour of the —, which I have duly considered.

Although this firm does not usually undertake business of this kind, which, from its nature, is more suited to a banking firm, yet Messrs. T. P. & Co.'s recommendation of your esteemed firm is of such a nature that I have no objection to opening a credit for your account to the extent of £5,000, in favour of Messrs. A. T. & Co. of New Orleans, upon the following conditions:

Messrs. A. T. & Co. will draw on me at 60 days' sight to the extent of the sum mentioned, sending me the bills of lading for each consignment of cotton on the same day as they negotiate the bills.

This firm will attend to the marine insurance for your account, and

Londres.

Sres ———
Barcelona.

Muy Sres mios,

Correspondo á su apb^le^ del—de cuyo contenido he quedado bien impuesto.

Aunque esta su casa no se ocupa de esa clase de negocios, que por su indole son mas propios de casas bancarias, es tal la recomendacion que nuestros amigos los Sres T. P. y Cia me han hecho de su respetable casa, que no tengo inconveniente en abrir un crédito por cuenta de Vds hasta £5,000, à favor de los Sres A. T. y Cia de Nueva Orleans, en las condiciones siguientes.

Los Sres A. T. y Cia giraran á mi cargo á 60 dias vista hasta dicha suma, remitiendoseme los conocimientos de embarque de cada partida de algodon en la misma fecha en que se negocien los giros.

El seguro maritimo lo cubrirá esta su casa por cuenta de Vds y 8 dias

eight days before Messrs. A. T. & Co.'s bills fall due I will draw on you at three months at the current rate of exchange for the amount, plus the insurance premium and my commission of 1% (one per cent.). I have no doubt that these conditions will meet with your approval, and that our business relations will be lasting and profitable.	antes del vencimiento de los giros, de los Sres A. T. y Cia de Nueva Orleans, giraré á cargo de Vds y á 3 meses fecha, al cambio corriente, por su valor más la prima del seguro y mi comision de 1% (uno por ciento). No dudo que estas condiciones le serán aceptables y confiando que nuestras relaciones comerciales serán duraderas y de mucho provecho me reitero con este motivo á sus ordenes ato S.S. q.s.m.b.
I remain, Yours faithfully, JOHN BROWN.	JOHN BROWN.

IDIOMATIC PHRASES

Abrir la mano, to take bribes
Alegrar las luces, to snuff the candles
Amontarse el juicio, to lose presence of mind
Andando el tiempo, in the course of time
Andar en coplas, to be the talk of the town
Andar en dimes y diretes, to wrangle
Aporrearse en la jaula, to strive in vain
A puño cerrado, with might and main
Armar caballero, to dub a knight
Armar un lazo, to set a trap
Arrimar el hombro, to lend a hand
A sus anchas, to be at one's ease
Bailar el pelado, to have no money
Bailar sin són, to be very eager
Buscar á tientas, to grope
Buscar cinco pies al gato, to pick a quarrel
Cantar de plano, to make full confession
Cebar un anzuelo, to bait a fish-hook
Cenar á oscuras, to be stingy
Coger la calle, to run away
Coger una liebre, to fall in the mud
Comer con gana, to eat with a good appetite
Contados sus alfileres, to be dressed in one's best
Contar paparruchas, to tell incredible tales; to draw the long bow
Costar un ojo, to be very expensive
Dar á conocer, to introduce people to each other
Dar el pésame, to condole
Dar el traste, to let go to rack and ruin
Dar en blando, to succeed easily
Dar fin, to end
Dar los dias, to wish "many happy returns"
Dar mal rato, to cause uneasiness
Dar una carcajada, to burst out laughing
Dar voces, to cry out
De cuando acá? since when?
De socapa, secretly, under protest
Dejar entre renglones, to forget to say something
Dejar el siglo, to become a monk or nun
Descabezar el sueño, to take a nap; "forty winks"
Echar coche, to set up a carriage
Echar el cuerpo fuera, to abscond
Echar la casa por la ventana, to be wild with delight
El me ha puesto un hierro, he has put me under a deep obligation
En seco, without cause
Es cuanto cabe, it is the last straw
Eso ni me va ni me viene, it is not my business
Estar con cuidado, to be anxious
Estar de ver, to be worth seeing
Estar mascando tierra, to be dead and buried
Estar sin habla, to be speechless
Hacer cuerpo presente, to put in an appearance
Hacer la cuenta de la vieja, to count up on one's fingers
Hacerse el tonto, not to take notice
Hacerse pedazos, to fall to pieces
Ir chiticallando, to creep on tip-toe
Llevarse chasco, to be disappointed
Mas que le pese, in spite of him
Meterse á sabio, to pretend knowledge
No poder parar, to be restless
No poder tragar á alguno, to hate anyone
No ser cojo ni manco, to be neither lame nor one-armed (in no way handicapped)
No tener seso, to have no common-sense
Pensar en los musarañas, to go "wool gathering"
Perdido por una persona, to be deeply in love
Poner en seco, to change one's clothes
Poner gesto, to show anger in one's face
Poner pies en pared, to put one's foot down
Probar mal la tierra, to prove a climate unsuitable
Quebrarse la cabeza, to puzzle one's head
Quedar sin novedad, to be well
Quejarse de vicio, to complain without cause
Repararen pelillos, to take offence at trifles
Reteñir las orejas, to grate on the ear
Romper la voz, to train the voice
Sacar la cara por otro, to defend another
Salir á gatas, to have a narrow escape
Seis años á esta parte, six years to this time
Ser de corona, to be in holy orders
Ser muy hombre, to be very manly
Sin ton y sin son, without rhyme or reason
Son las ocho en punto, it is eight precisely
Tener mucha mosca, to be very rich
Tocar la diana, to sound the reveille
Tomar rabia, to get angry
Volver casaca, to become a turncoat

ABBREVIATIONS

Admit^{dor}	Administrador	Trustee
Af^{mo}	Afectisimo	Yours truly (literally, most affectionate)
Ag^{to}	Agosto	August
Apt^{lco}	Apostólico	Apostolic
Art^{o}	Articulo	Article
Arzbp^{o}	Arzobispo	Archbishop
B. L. P.	Besa los piés	Kisses your feet (at the close of a letter addressed to a lady)
C. M. B.	Cuyas manos beso	Who kisses your hands (addressing a gentleman)
C. P. B.	Cuyos pies beso	Who kisses your feet
Cap^{tlo}.	Capitulo	Chapter
Cap^{tn}.	Capitan	Captain
Comp^{a}.	Compañia	Company
Corr^{te}.	Corriente	Current
Dicb^{re}	Diciembre	December
D^{r}	Doctor	Doctor
E. A. L. P. D. V^{d}	Estoy á los piés de V^{d}	I am at your disposal (I am at your feet)
En^{o}	Enero	January
Excm^{o}	Excelentisimo	Excellency
Feb^{ro}	Febrero	February
Gen^{l}	General	General
Ig^{la}	Iglesia	Church
Il^{tre}	Ilustre	Illustrious
Ill^{mo}	Ilustrisimo	Most illustrious
Lbas	Libras	Pounds (weight)
Maj^{tad}	Majestad	Majesty
Novb^{re}	Noviembre	November
Ntro	Nuestro	Ours
Obp^{o}	Obispo	Bishop
Oct^{bre}	Octubre	October

Pág^a	Página	Page	S^r D^n	Señor Don	Mr.
P. D.	Posdata	Postscript	S.S.M.M. y A. A. R. R.	Sus Majestades y Altezas Reales	Your Majesties and Royal Highnesses
Pp^do	Proximo pasado	Ultimo	S. S. S.	Su Seguro Servidor	Yours very obediently
Proc^dor	Procurador	Lawyer	S. S^tdad	Su Santidad	Your Holiness
Sept^bre	Septiembre	September	St^a.	Señorita	Miss
Ser^dor	Servidor	Servant	S^tmo	Santisimo	Most Holy
Ser^mo	Serenisimo	Most Serene	S^to	Santo	Saint
Sig^te	Siguiente	Following	Ten^te	Teniente	Lieutenant
S^or	Señor	Sir	V. A.	Vuestra Alteza	Your Highness
S^ra	Señora	Madam, Ladyship	V. G.	Verbigracia	For example
S^ra D^a	Señora Doña	Mrs			

SPANISH *concluded*

ESPERANTO
Continued from page 6094

By Harald Clegg

Participial Adjectives
(ACTIVE VOICE)

From all Esperanto verbs, whether transitive or intransitive, compound tenses may be formed by means of the various forms of the auxiliary *esti*, and the participles.

The auxiliary remains the same for each person, the participle alone agreeing with the subject in number.

The present participle (active voice) is *anta* (sing.), *antaj* (plural).

The past participle (active voice) is *inta* (sing.), *intaj* (plural).

The future participle (active voice) is *onta* (sing.), *ontaj* (plural).

In order to simplify the explanation of the participles, both active and passive, one pronoun (*mi*) and one verb (*lavi*) will be used throughout. Nine compound tenses can be formed by combination of the three active participles with the three tenses of the auxiliary verb. (These participles may also be combined with *esti*, *estus* and *estu*.)

Mi estas lavanta, I am washing; ***Mi estas lavinta***, I have washed (lit. I am having washed); ***Mi estas lavonta***, I am about to wash.

Mi estis lavanta, I was washing; ***Mi estis lavinta***, I had washed (lit. I was having washed); ***Mi estis lavonta***, I was about to wash.

Mi estos lavanta, I shall be washing; ***Mi estos lavinta***, I shall have washed (lit. I shall be having washed); ***Mi estos lavonta***, I shall be about to wash.

Mi estus lavanta, I should be washing; ***Mi estus lavinta***, I should have washed (lit. I should be having washed); ***Mi estus lavonta***, I should be about to wash.

The present, past and future infinitives are expressed by *esti lavanta*, to be washing; *esti lavinta*, having washed; *esti lavonta*, to be about to wash.

The participles are in reality adjectives, and when predicated of a plural noun or pronoun must take the final "j": ***Ni estas lavantaj***, We are washing. The participles may also be used to qualify directly a noun or pronoun, in which case they accord with such noun or pronoun both in number and case.

Example: *La tempo pasinta neniam revenos; la tempon venontan neniu aŭkoraŭ konas* (Zamenhof), The time passed never will return; the time to come nobody yet knows.

Careful thought must be used in constructing these compound tenses, and the exact meaning of the participle in reference to the auxiliary must be fully understood.

When *anta* is used it indicates that the action is still in progress at the time indicated by the auxiliary.

When *inta* is used it indicates that the action was completed at the time indicated by the auxiliary.

When *onta* is used it indicates that the action is about to take place at the time indicated by the auxiliary.

The student should compare these remarks with the foregoing table of the compound tenses, and at the same time note that the English auxiliary "to have" is always rendered by *esti*, the sole auxiliary verb in Esperanto.

The compound tenses, though perhaps appearing a little complex to beginners who have so far remarked the extreme simplicity of the language, give a precise shade to the meaning which one wishes to render. In practice, nevertheless, whenever the compound forms can be dispensed with, the simple tenses are used if they adequately fulfil the requirements of the sense to be conveyed. Thus the simple *mi lavos* may be used to signify I wash, I do wash, and I am washing.

Impersonal Verbs

Those Esperanto verbs which by their nature are impersonal do not require the use of the indefinite pronoun as in English.

Examples: *Pluvos*, It will rain; *Estas tondre*, It is thundery; *Mi pensas, ke neĝos morgaŭ*, I think it will snow to-morrow.

The words "it" and "there" in "it is," "there is," "there are," "there was," "there will be," etc., when used indefinitely, are never translated.

Examples: *Estas necese*, It is necessary; *Estos sufiĉe da tempo poste*, There will be enough time later; *Estis multe da homoj tie*, There were many people there.

Other examples of similar usage are: *Ŝajnas al mi, ke . . .* It seems to me that . . . .; *Okazos kunsido*, There will be a meeting (a meeting will be held); *Se plaĉas al vi*, If you please (if it please you).

Suffixes

AĴ denotes something made from, or having the quality contained in the root word.

Examples: *Bona*, good; *bonaĵo*, a good thing; *grava*, important; *gravaĵo*, an important thing; *bovo*, ox; *bovaĵo*, beef.

EBL denotes possibility (to *be*, not to *do*).

Examples: *Kredi*, to believe; *kredebla*, credible; *legi*, to read; *legebla*, legible.

IND denotes worthiness.

Example: *Laŭdi*, to praise; *laŭdinda*, praiseworthy; *legi*, to read; *leginda*, readable.

EC denotes an abstract quality.

Examples: *Varma*, warm; *varmeco*, warmness, warmth; *frato*, brother, *frateco*, brotherliness.

Vocabulary

bros', brush
brust', chest, breast
brut', brute, cattle
ĉagren', disappoint, vex
ĉen', chain
defend', defend
degel', thaw
dron', drown (v. i.)
except', except
faktur', invoice
fold', fold
flam', flame
fortik', strong, robust
frost', frost
fulm', lightning
gren', corn,
hajl', hail (subst.)
klin', bend, incline
konsist', consist

konstant', constant
lan', wool
melk', milk (v.)
merit', merit, deserve
ofend', offend
ombrel', umbrella
ordon', order, command
plac', public square
pluv', rain
polic', police
polv', dust
postul', require, demand
pretend', claim
pump', pump (v.t.)
regn', realm, kingdom
regul', rule (s.)
rezultat', result
ripoz', repose, rest
ruĝ', red
ruz', trick, ruse
sabl', sand
salut', greet, salute
sam', same
sav', save, rescue
sent', feel, perceive
soif', thirst
sol', only, alone
spir', breathe
ŝang', change
trem', tremble

EXERCISE XVI.

(NOTE. Translate the compound tenses as they appear in English.)

It blows strongly outside. When he had folded (was having folded) the invoice and written his address on the envelope, he gave both to me. What strange weather it is to-day! Sometimes it snows, sometimes hails, sometimes lightens and thunders. One can never be certain about it. This chain has 37 links, each one of (out of) gold. He does not like frosty weather, and is always happy when it commences to thaw. He was defending. They are about to milk. I shall have changed (shall be having changed). We are not claiming. You will have saved. He was about to defend. I had offended. They will have rested. I have ordered. She is breathing. Those who are about to die salute you. They have offended me. They were just going to save her. The villager had milked her cows. The policeman is peacefully sleeping. I feel as though I am about to die. If I had had an umbrella, I could have visited you in spite of the rain. A grain of dust had fallen into her eye. She was trembling, and could hardly breathe. If they had known the rules, they would not have made the same error twice. The blind man was about to fall into the flames, when that courageous person saved him.

KEY TO EXERCISE XV.

Permesu, mi petas, ke mi pasu! Kia domaĝo ke vi ne kaptis la krimulon! Ĉiuj bonaj urbanoj renkontu min ĉi tie morgaŭ por ke ni kune portu nian peton al la reĝo. Akveregoj ekfalis de la plafono. Iru rekte ĝis kiam vi atingos la arbaron, kaj zorgu por eviti ĉiujn vojojn kiuj kondukas maldekstren kaj dekstren. La penso pri tiu mizera avarulo kaŭzas al mi multan doloron. Ricevu, sinjoro, miajn plej korajn dankojn. Rigardu tiun insektaron. Estu paco en la mondo kaj senfina konvolo en la koroj de homoj. Ĝi estu tiel. Antaŭ dek du jaroj mi fondis tiun ĉi grupon, kaj nun la membraro nombras tricent dek kvin. Bone, amiko mia, mi vin gratulas. Vi ĉiam sukcesu kiel antaŭe! Kiel dolĉe odoras tiuj floroj! Fajrero povas kaŭzi brulegon. Kvankam mi ne efektive konas ion malbonan pri tiu persono, mi tamen malkonfidas al li, sed preferas konservi mian propran opinion pri li nuntempe. Jen estas klubano, kiu kolektas monerojn. Estas necese ke vi lernu parkere la tutan radikaron en ĉi tiuj vortaretoj. La muŝo rampis sur la korpo de la kapro. Kolektu (vi) la pinglojn kaj enpaku ilin en la skatoleton.

Continued

GREEK

Continued from page 6096

By G. K. Hibbert, M.

SECTION I. VERBS

Contracted Verbs. Verbs in *αω*, *εω*, and *οω* are contracted in the present and imperfect tenses. The following are the contracted tenses of *τιμάω*, I honour; *φιλέω*, I love; and *δηλόω*, I manifest.

ACTIVE VOICE

Present Indicative

τιμῶ (for τιμάω)	φιλῶ	δηλῶ
τιμᾷς (for τιμάεις)	φιλεῖς	δηλοῖς
τιμᾷ (for τιμάει)	φιλεῖ	δηλοῖ
τιμᾶτον, etc.	φιλεῖτον	δηλοῦτον
τιμᾶτον	φιλεῖτον	δηλοῦτον
τιμῶμεν	φιλοῦμεν	δηλοῦμεν
τιμᾶτε	φιλεῖτε	δηλοῦτε
τιμῶσι (ν)	φιλοῦσι (ν)	δηλοῦσι (ν)

Imperfect Indicative

ἐτίμων (ἐτίμαον)	ἐφίλουν	ἐδήλουν
ἐτίμας	ἐφίλεις	ἐδήλους
ἐτίμα	ἐφίλει	ἐδήλου
ἐτιμᾶτον	ἐφιλεῖτον	ἐδηλοῦτο
ἐτιμάτην	ἐφιλείτην	ἐδηλούτην
ἐτιμῶμεν	ἐφιλοῦμεν	ἐδηλοῦμεν
ἐτιμᾶτε	ἐφιλεῖτε	ἐδηλοῦτε
ἐτίμων	ἐφίλουν	ἐδήλουν

Present Subjunctive

Same as Present Indicative	φιλῶ	δηλῶ
	φιλῇς	δηλοῖς
	φιλῇ	δηλοῖ
	φιλῆτον	δηλῶτον
	φιλῆτον	δηλῶτον
	φιλῶμεν	δηλῶμεν
	φιλῆτε	δηλῶτε
	φιλῶσι	δηλῶσι

Present Optative

τιμῷμι (τιμάοιμι)	φιλοῖμι	δηλοῖμι
τιμῷς	φιλοῖς	δηλοῖς
τιμῷ	φιλοῖ	δηλοῖ
τιμῷτον	φιλοῖτον	δηλοῖτον
τιμῴτην	φιλοίτην	δηλοίτην
τιμῷμεν	φιλοῖμεν	δηλοῖμεν
τιμῷτε	φιλοῖτε	δηλοῖτε
τιμῷεν	φιλοῖεν	δηλοῖεν
or	*or*	*or*
τιμῴην (τιμαοίην)	φιλοίην	δηλοίην
τιμῴης	φιλοίης	δηλοίης
τιμῴη	φιλοίη	δηλοίη
τιμῴητον	φιλοίητον	δηλοίητον
τιμῳήτην	φιλοιήτην	δηλοιήτην
τιμῴημεν	φιλοίημεν	δηλοίημεν
τιμῴητε	φιλοίητε	δηλοίητε
τιμῴησαν	φιλοίησαν	δηλοίησαν

Present Imperative

τίμα	φίλει	δήλου
τιμάτω	φιλείτω	δηλούτω
τιμᾶτον	φιλεῖτον	δηλοῦτον
τιμάτων	φιλείτων	δηλούτων
τιμᾶτε	φιλεῖτε	δηλοῦτε
τιμάτωσαν or τιμώντων	φιλείτωσαν or φιλούντων	δηλούτωσαν or δηλούντων

Present Infinitive

τιμᾶν (τιμάειν)	φιλεῖν	δηλοῦν

Present Participle

τιμῶν, ῶσα, ῶν	φιλῶν, οῦσα, οῦν	δηλῶν, οῦσα, οῦν

Passive and Middle

Present Indicative

τιμῶμαι	φιλοῦμαι	δηλοῦμαι
τιμᾷ	φιλεῖ	δηλοῖ
τιμᾶται	φιλεῖται	δηλοῦται
τιμᾶσθον	φιλεῖσθον	δηλοῦσθον
τιμᾶσθον	φιλεῖσθον	δηλοῦσθον
τιμώμεθα	φιλούμεθα	δηλούμεθα
τιμᾶσθε	φιλεῖσθε	δηλοῦσθε
τιμῶνται	φιλοῦνται	δηλοῦνται

Imperfect Indicative

ἐτιμώμην	ἐφιλούμην	ἐδηλούμην
ἐτιμῶ	ἐφιλοῦ	ἐδηλοῦ
ἐτιμᾶτο	ἐφιλεῖτο	ἐδηλοῦτο
ἐτιμᾶσθον	ἐφιλεῖσθον	ἐδηλοῦσθον
ἐτιμάσθην	ἐφιλείσθην	ἐδηλούσθην
ἐτιμώμεθα	ἐφιλούμεθα	ἐδηλούμεθα
ἐτιμᾶσθε	ἐφιλεῖσθε	ἐδηλοῦσθε
ἐτιμῶντο	ἐφιλοῦντο	ἐδηλοῦντο

Present Subjunctive

Same as Present Indicative	φιλῶμαι	δηλῶμαι
	φιλῇ	δηλοῖ
	φιλῆται	δηλῶται
	φιλῆσθον	δηλῶσθον
	φιλῆσθον	δηλῶσθον
	φιλώμεθα	δηλώμεθα
	φιλῆσθε	δηλῶσθε
	φιλῶνται	δηλῶνται

Present Optative

τιμῴμην	φιλοίμην	δηλοίμην
τιμῷο	φιλοῖο	δηλοῖο
τιμῷτο	φιλοῖτο	δηλοῖτο
τιμῷσθον	φιλοῖσθον	δηλοῖσθον
τιμῴσθην	φιλοίσθην	δηλοίσθην
τιμῴμεθα	φιλοίμεθα	δηλοίμεθα
τιμῷσθε	φιλοῖσθε	δηλοῖσθε
τιμῷντο	φιλοῖντο	δηλοῖντο

Present Imperative

τιμῶ (τιμάου)	φιλοῦ	δηλοῦ
τιμάσθω	φιλείσθω	δηλούσθω
τιμᾶσθον	φιλεῖσθον	δηλοῦσθον
τιμάσθων	φιλείσθων	δηλούσθων
τιμᾶσθε	φιλεῖσθε	δηλοῦσθε
τιμάσθωσαν or τιμάσθων	φιλείσθωσαν or φιλείσθων	δηλούσθωσαν or δηλούσθων

Present Infinitive

τιμᾶσθαι	φιλεῖσθαι	δηλοῦσθαι

Present Participle

τιμώμενος, η, ον	φιλούμενος, η, ον	δηλούμενος, η, ον

Note. A few verbs in αω take η for α in their contracted forms; of these the commonest are: ζάω, live; διψάω, thirst; πεινάω, hunger; κνάω, scrape; ψάω, rub; χράω, give oracles; and χράομαι, use. Thus, ζῆν, to live; διψῇς, thou thirstest; χρῆσθαι, to use.

SECTION II. SYNTAX

The Accusative Case

The accusative always depends on a verb, or on a verbal notion in a noun. It may denote:

1. External object; 2. Internal object (including the accusative of result and the cognate accusative; 3. Aim; 4. Extent; 5. Relation (including the accusative of the part affected, and the limiting accusative).

1. External Object. This is the ordinary use of the accusative, to limit or direct the action of the verb—as: τοῦτο ποιοῦμεν, We do this; ἡ πίστις σου σέσωκέ σε, Thy faith hath saved thee.

An intransitive verb—*i.e.*, one whose meaning is complete in itself, may be used transitively by an extension of its meaning—*e.g.*, λανθάνω, I lie hid; φεύγω, I flee; φθάνω, I am first. Thus, λανθάνουσι τοὺς φύλακας, They escape the notice of the guards; φεύγει τὸν πατέρα, He flees from (shuns) his father; ἔφθησαν (from φθάνω) τὸν χειμῶνα, They anticipated the storm; ὄμνυμι τοὺς θεούς, I swear by the gods.

This accusative is frequent in expressions of emotion, a verb being understood—as: νὴ τὸν Δία, Yes, by Zeus; μὰ τὸν Δία, No, by Zeus; οὐ τὸν ἥλιον, No, by the sun (I swear).

2. Internal Object. The accusative repeats with more or less modification of meaning the idea given by the verb. Under this we have:

(*a*) Accusative of Result—as: πημονὰς ἐρεῖς, You will give pain by speaking (lit. you will speak pains); βοθρὸν ὤρυξε, He dug a hole. With this may be reckoned the accusative in apposition to the whole sentence, denoting the result of the action of the verb—as: Ἑλένην κτάνωμεν, Μενελέῳ λύπην πικράν, Let us kill Helen, (which will be) bitter grief to Menelaus.

(*b*) The Cognate Accusative, noun and verb having a common stem—as: βουλὰς βουλεύειν, to plan plans; ἀποστήσεσθαι διπλῆν ἀπόστασιν, to revolt a double revolt. Under this heading comes what is often called the adverbial accusative, where a noun, pronoun, or adjective is used in the accusative case with an adverbial meaning—as: προφάσιν, ostensibly; καιρόν, opportunely; πᾶσαν ἰδέαν, in every way; δίκην, like; χάριν, for the sake of; τοῦτον τὸν τρόπον, in this way; τέλος, finally; τί, in what respect; πρῶτον, at first; τὸ λοιπόν, for the rest; οὐδέν, not at all.

Under the head of Internal Object must be placed the *Accusative Absolute*, usual with the participles of certain impersonal verbs—as: δέον, it being a duty; ἐξόν, it being allowed; προσῆκον, it being fitting; δόξαν, it having been decided; μετόν, παρόν, ὑπαρχόν, τυχόν, δεδογμένον, εἰρημένον (though it had been stated). κ. τ. λ. Example: οὐδεὶς (ἐξὸν εἰρήνην ἄγειν) πόλεμον αἱρήσεται, No one (when it is possible to have peace) will choose war.

3. Accusative of Aim, or "Terminus ad quem," after verbs of motion. In prose this is preceded by a preposition, such as πρός, εἰς, ἐπί, to, towards, against, etc. But in poetry it is found without a preposition—as: ἔβης Θήβας,

Thou didst go to Thebes (Sophocles); χρεία τίς σε Θεσσαλῶν χθόνα πέμπει, Some necessity sends thee to the land of the Thessalians.

4. Accusative of Extent. (*a*) Extent of space—as: ἀπέχει δ' ἡ Πλάταια τῶν Θηβῶν σταδίους ἑβδομήκοντα, Platæa is distant from Thebes 70 stades. (*b*) Duration of time—as: ἡμέρας ἔχουν (= ἔχεον, from χέω) ἑβδομήκοντα, They worked at the mound for 70 days.

5. Accusative of Relation, Respect, Reference, or Definition. (*a*) Of the part affected—as: ἀλγεῖ τοὺς ὀδόντας, He has a pain in his teeth; πόδας ὠκύς, swift of foot (lit. swift as to his feet). (*b*) Accusative of Limitation, used in certain common words, as: μέγεθος (in size), ὄνομα (by name), γένος, φύσιν—*e.g.*, διαφέρει τὴν φύσιν, He differs in nature; Ἕλληνές εἰσι τὸ γένος, They are Greeks by race.

Double Accusative: 1. After verbs of making, thinking, finding, naming, appointing, etc.—as: στρατηγὸν αὐτὸν ἀπέδειξε (ἀποδείκνυμι), He appointed him general.

2. After verbs of asking, teaching, concealing, taking away, clothing, unclothing, reminding, depriving, etc.—as: Θηβαίους χρήματα ᾔτησαν (from αἰτέω), They asked the Thebans for money; μή με κρύψῃς ταῦτα, Do not hide this from me; ἀναμιμνήσκειν τοὺς Ἀθηναίους τὴν συμμαχίαν, to remind the Athenians of the alliance.

3. After verbs of doing anything to, or saying anything of a person—as: δρᾶν τινά τι, to do something to someone; εὖ ποιεῖν τινά, to benefit someone; πλεῖστα κακὰ τὴν πόλιν ποιοῦσιν, They do the most evils to the state. [Note. εὖ πράσσω means: I fare well, *not* I do good to someone].

SECTION III. TRANSLATION.

The student has now reached a stage when he may profitably begin to read some of the Greek authors. For his guidance a list of the most commonly read authors is here given. One or two books of a prose writer should be read before any works of the poets are attempted.

Prose Writers. 1. Xenophon (B.C. 430–354), historian, wrote "Anabasis," "Hellenica," "Cyropædia," etc.

2. Thucydides (B.C. 471–400), historian, wrote "History of the War between Athens and Sparta," in eight books.

3. Herodotus, "the father of history" (B.C. 484–420), wrote a history of early Greece.

4. Demosthenes (B.C. 384–322), orator, was the author of several magnificent speeches.

5. Plato (B.C. 429–347), philosopher, disciple of Socrates, wrote "The Republic," "The Apologia of Socrates," and several philosophical treatises.

Poets. 1. "The Works of Homer," the great epic poem of Greece (compiled B.C. 940–850), including the "Iliad" and the "Odyssey."

2. Æschylus (B.C. 525–456),
3. Sophocles (,, 495–405),
4. Euripides (,, 480–406), } the great tragedians of Greece.

Æschylus wrote "The Seven against Thebes," "The Agamemnon," "The Persæ," "Prometheus Bound," "The Eumenides," "The Choephoræ," "The Suppliants," etc. Sophocles wrote "Œdipus Rex," "Antigone," "Ajax," "Philoctetes," "Œdipus Coloneus," etc. Euripides wrote "Medea," "Bacchæ," "Hippolytus," "Hercules Furens," "Iphigenia in Tauris," "Alcestis," "Electra," "Andromache," "The Cyclops," "Hecuba," "Ion," etc.

5. Aristophanes, comic poet, (B.C. 448–380), wrote "The Clouds," "The Frogs," "The Knights," "Plutus," "The Wasps," "The Acharnians," "The Birds," "The Ecclesiazusæ" ("Women in Parliament"), etc.

Xenophon's "Anabasis" is a good book to begin on, and after reading some of it the student might try a book of Thucydides. He will find Thucydides much harder than Xenophon. Not until he has read something of these authors should he try poetry. The best of the poets to begin on is Euripides (say, "The Medea").

Herodotus and Homer should be left till a little later, as they are earlier than the classical period, and their Greek is not "classical." Æschylus is perhaps the most difficult of the poets, and to appreciate the works of Plato (except the "Apologia Socratis") the student needs some acquaintance with philosophy. A rough working knowledge of Greek history is essential, and Abbott's "History of Greece" (Rivington), in two volumes, is recommended. Also the late Prof. Jebb's "Greek Literature" (Macmillan, 1/-) should be procured.

Students desirous of studying the New Testament in Greek are advised to procure one of the Gospels in "White's Grammar School Texts," published by Longmans, 1s. each.

With regard to English translations of Greek authors, among the finest are Jowett's "Republic of Plato" and "Thucydides," Jebb's "Sophocles," Campbell's "Sophocles" and "Æschylus" (World's Classics Series), Butcher & Lang's "Odyssey," and Lang, Myers, & Leaf's "Iliad." The translations in Bohn's series are literal, but hardly inspiring.

Key to Translation (page 6096)

Indian Rivers

And at that time all the Indian rivers* were flowing both great and turbid and with a swift current: for it was the season of the year. And at this season the waters from heaven are carried down in heaps to the Indian land,* and the snows of the Caucasus (whence are the sources of many of the rivers) increase their water. But in winter they become small and clear to see and all passable, except, at least, the Indus and the Ganges.

* For "the Indian rivers" Greek says either οἱ Ἰνδοὶ ποταμοί (the simple and natural order), or οἱ ποταμοὶ οἱ Ἰνδοί (as here), or even ποταμοὶ οἱ Ἰνδοί; but *not* οἱ ποταμοὶ Ἰνδοί, for that would mean "the rivers (are) Indian." This latter is the *predicative* use of the adjective, the former being the attributive.

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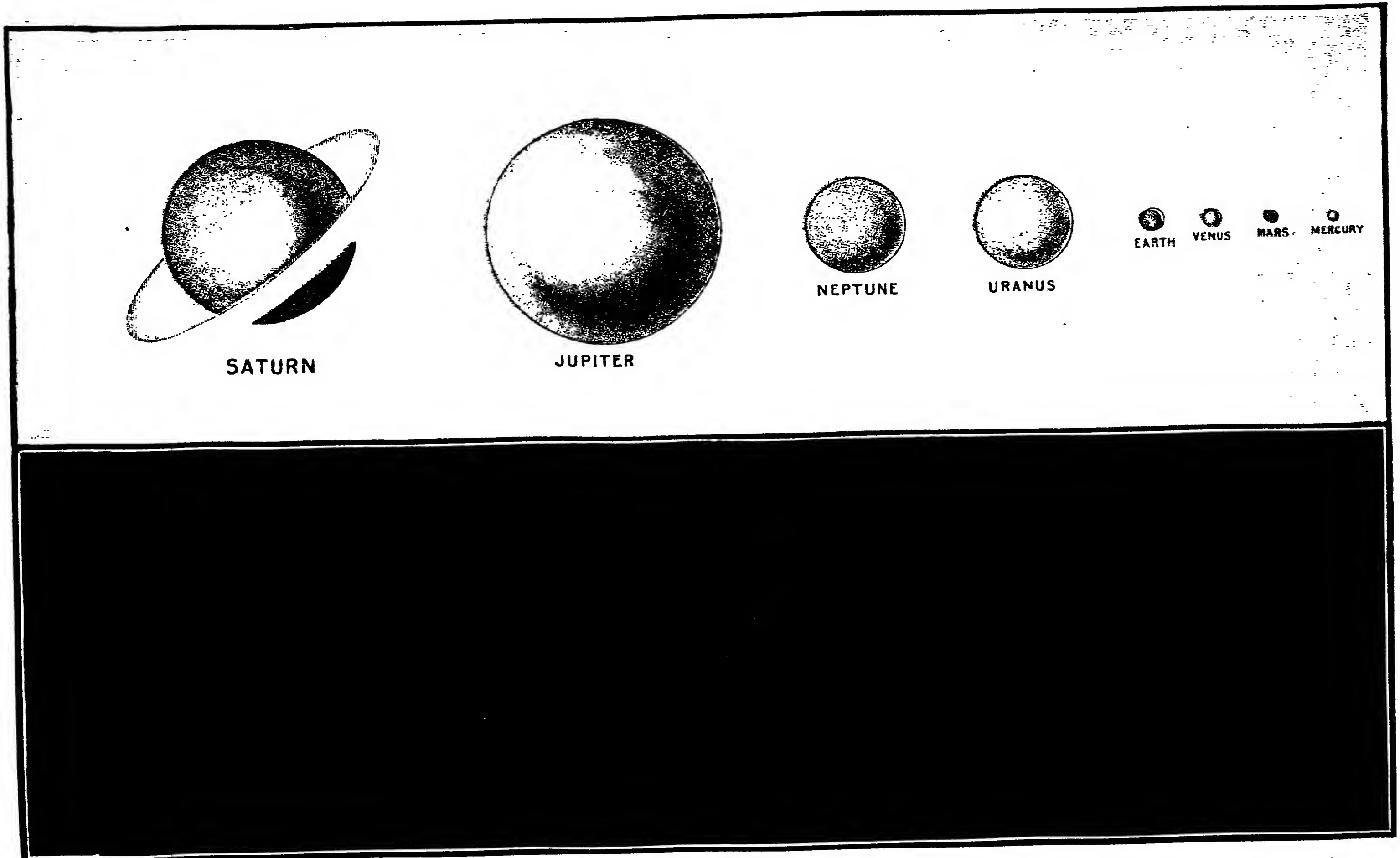


THE PRINCIPAL PLANETS, WITH THE EDGE OF THE SUN UNDER ECLIPSE

Showing the rings of Saturn and the sizes of the planets, relative to one another and to the sun. The scarlet prominences shown in the plate are visible only when the sun is eclipsed. [See ASTRONOMY.]

LAWS OF THE UNIVERSE

The Laws of the Planets' Motions. Star Measurements. Transit and Equatorial Telescopes. Astronomical Chemistry. The Sun and its Spots. The Life of the Sun

Group 13
ASTRONOMY
2

Continued from page 6121

By W. E. GARRETT FISHER

BEFORE considering the solar system in detail, we must glance at the methods by which the successors of Copernicus ascertained its real movements and relations. Even after Copernicus had persuaded men—not without much opposition—that the earth moved round the sun like the other planets, nearly two centuries passed before the actual laws governing planetary motion were clearly understood.

The First Astronomers. Tycho Brahé (1546—1601), who was the first of the great practical astronomers of modern times, made a series of wonderful and accurate observations of the stars. When we think that he had not the advantage of using a telescope, these observations were remarkably exact, and they provided the material on which the genius of John Kepler worked. Kepler (1571—1630), who was a pupil of Tycho Brahé, undertook to calculate from these observations how the planets ought to move round the sun in order, at all times, to hold the positions in which they were actually found. We can hardly realise the many difficulties of this task, which Kepler carried out by what is known as the Method of Trial and Error. That is to say, he had the unwearied patience to work out the consequence of every possible law of motion which his fertile imagination could suggest. All that he knew for certain was that at certain times the various planets occupied such and such places in the sky. Ultimately, by the aid of the perseverance which amounts to genius, he was successful in discovering the true orbits and laws under which the planets move in them. These laws, known for all time by the name of Kepler, are three in number.

Kepler's Laws of Planetary Motion.
1. The orbit of each planet is an ellipse, having the sun in one focus.
2. As the planet moves round the sun its radius vector describes equal areas in equal times.
3. The square of the time in which each planet completes its orbit is proportional to the cube of its mean distance from the sun.

These laws cannot be fully understood without some acquaintance with mathematics, which, of course, is a necessary prelude to all but the most elementary astronomical work. They may, however, be briefly explained for the comprehension of the non-mathematical reader. The figure in the diagram [7] is an ellipse—what is known in popular language as an oval—which is symmetrical about the line AB, known as its major axis. It has two foci, S and S_1. The fundamental law of the ellipse is that if we take any point P on it, and join this point by a straight line to the two foci, then the sum of these two lines SP and S_1P is always the same—$SP + S_1P = C$. This enables us to draw an ellipse in practice by fastening a piece of string to S and S_1 with drawing pins, placing a pencil in the angle SPS_1, and running it round, so as to keep the string taut. Kepler's first law means that a planet always moves in an orbit of this shape, each planet describing a different ellipse.

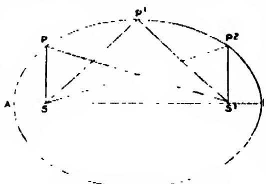
The second law is rather less easy to understand. The *radius vector* is the line joining the sun to the planet at any moment; if we suppose the sun to be at the focus S, and P to be the planet, the radius vector at various positions of the planet will be represented by the lines SP, SP_1, SP_2, etc. If the positions P, P_1, P_2, etc., represent those which the planet occupies after equal periods of time—say, once a month—then the sectors of the ellipse bounded by each pair of lines, SP and SP_1, SP_1 and SP_2, will be equal. If a planet were to move in a circle round the sun, it is obvious that this law would imply that it moved with a uniform speed, but since the curvature of the ellipse varies in every part of its course, so must the speed of the planet in order that its radius vector may describe equal areas in equal times. The planet will, in fact, be moving faster when it is near the sun, as at P, than when it is far off from the sun, as at P_2.

Kepler's third law shows that there is a definite numerical relation between the motions of all the planets, and that the time which each of them takes to complete its orbit depends upon its distance from the sun. We cannot explain in an elementary course why this relation should assume the particular form given to it in Kepler's law, but the reader must take it for granted that this is a necessary consequence of the physical laws under which the planets move.

The Discovery of the Telescope. The next great step in the history of astronomy was taken when the Italian Galileo (1564—1642) discovered the telescope about the year 1609. There is some dispute as to how far the discovery of the fact that two lenses placed in a certain relation to one another [see PHYSICS, page 2901] would magnify distant objects, or bring them apparently nearer to the observer, was Galileo's, but there is no doubt that Galileo was the first to apply this discovery to the study of the stars. His first telescope [8], which was about equal in power to the instrument which can nowadays be bought at a toy shop for two or three shillings, showed him that the moon was another world like our own, with mountains and valleys, rocks and volcanoes, plains, and apparently seas and rivers—though we now know that this was a mistake. Galileo's next discovery with a more powerful telescope was the existence of countless stars which were invisible to the naked eye. The Milky Way, for instance, proved to be no mere luminous haze, but an assemblage of myriads of small stars. The next fruit of the telescope was the discovery that the planet Jupiter had satellites—four little moons, which were to become important as being the first addition made since history began to the numbers of the solar system. Lastly, Galileo discovered the wonderful rings which girdle the planet Saturn, and the existence of spots on the sun. The truth of these discoveries was fiercely assailed, and every schoolboy is familiar with the story of how Galileo was imprisoned by the Inquisition, and forced to recant his belief in the new

science of astronomy. But the progress of truth has never been seriously checked by obstacles of this kind, and Galileo's work served as the solid foundation of the vast and splendid fabric which has been reared by the labours of his followers. In addition to his purely astronomical work, he did a vital service to science by the discovery of the laws of motion, for which the student must consult the course on PHYSICS [pages 35 and 422].

Newton and the Law of Gravitation. The discovery of the telescope, in spite of the theologians, who wanted mankind to put it to their blind eye, like Nelson at Copenhagen, soon eliminated the objections which were still urged to the theories of Copernicus and his successors. The bounds of the solar system had been enlarged, the other planets had been discovered to be worlds like our own in miniature, their motions had been clearly established, and astronomy had now got the length of forming a conception of the whole solar system, much as we see it to-day, with the earth taking its place as a minor planet and sharing the motions of its fellows. But there was still no apparent reason in Nature for all these wonderful and complex movements. Kepler had determined the *how* of the planetary motions, and it remained for Sir Isaac Newton (1642-1727), one of the greatest names in modern science, to ferret out the *why*.



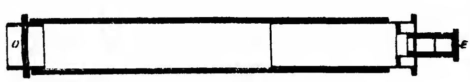
7. KEPLER'S LAWS

Newton, who was born in 1642 in a Lincolnshire village, showed an early genius for mathematics, and was sent to Cambridge, where he devoted his life to this study. Much of his work, which practically resulted in the foundation of modern mathematics, will be found described elsewhere. We have here to deal only with the great service that he did to astronomy. The problem of what should make the planets move, as Kepler had shown that they did, in elliptical orbits round the sun, and hold their steady motion without variableness or shadow of turning, soon presented itself to his wonderful mind as worthy of deep thought. In his own words, he "intended his mind upon this problem for many years," and at last he hit upon the solution. The common story is that it was the sudden fall of an apple from one of the trees in the orchard where he was sitting one summer day, revolving this great problem in his mind, that led the truth to flash upon Newton, and it is quite possible that this may be so. It is often a seemingly trivial accident that leads to a great discovery, just as a solid fragment dropped into a saturated solution makes it suddenly flash into crystals throughout.

The Action of Gravity. It had long been known, of course, that the falling of bodies was due to their weight or *gravity*, and that this simply meant that they were attracted by the earth. Newton did not discover the existence of gravitation, as is sometimes erroneously said. What he did was to apply the well-known force of gravitation to the work of keeping the planets in their orbits. The first law of motion, which Galileo discovered and Newton enunciated as the basis of physical science, asserts that a body continues to move always in the same *straight line unless it is deflected* by some external force. All bodies which, like the planets, move in closed orbits must be continually deflected from a straight line by some constantly acting force, competent to keep them moving obediently round the centre, or they would fly away for ever into the remote abysses of space. Newton was the first to perceive that the familiar force of gravitation, which brings a stone back to the earth after we have flung it away into the air, was also adequate to keep the planets from travelling on in straight lines.

The rate at which a body falls towards the earth is always the same at the same part of the earth's surface, though it varies slightly as we go towards the poles from the equator. Consequently we can calculate the distance which a projectile, starting with a given velocity from the earth's surface, will travel before it falls to the ground [see PHYSICS]. Such a projectile will reach the earth from the highest point of its flight in exactly the same time as if it were allowed to fall from that point. But we know that the earth is a sphere, and its surface is everywhere curved downwards from the straight line which is drawn tangentially to it. Suppose, now, that our projectile is fired along this straight line with such a velocity that by the time it has fallen down 10 ft. towards the earth it has reached a point where the earth's surface is curved 10 ft. downward from the direction from which the projectile was started. Clearly, although it has fallen freely under the attraction of gravitation, it will be no nearer the earth's surface than when it started. By the time it has fallen another 10 ft. the earth's surface will still have curved as far away from it, since the curvature of the sphere increases exactly at the same rate as the speed with which the body falls to the ground.

Thus our imaginary projectile, preserving its initial velocity, as it would do if there were no atmospheric resistance to check it, will also preserve its original distance from the earth, and will ultimately come back to the same place from which it started, after completing the circuit of the earth. If it is fired with a velocity less than we have supposed, it will reach the earth sooner or later; if with a velocity somewhat greater, it will travel away from the earth in a gradually widening spiral. But if the velocity is rightly chosen, our projectile will become a satellite perpetually circling the earth at the same distance. It is, of course, impossible to try such an experiment, even if we could impress the necessary velocity upon our projectile—as, indeed, in days of modern artillery is not outside the range of possibility. The resistance of the air would entirely upset the whole experiment. But the planets, and even our satellite, the moon, are far outside the reach of such a minor consideration; they move through the void of space, which is practically an absolute vacuum and presents no resistance whatever to their movement. Newton was led by some such train of thought to ask himself whether the fact that the moon was constantly falling towards the earth and at the same time moving always forward with a definite velocity, might not suffice to account for its continuance in its orbit.



8. GALILEO'S TELESCOPE
E. Eyepiece *O* Objective

The Law of the Inverse Square. By mathematically working out the consequences of Kepler's laws of planetary motion Newton discovered that these laws implied that the force which held all the planets moving round the sun

must be a force emanating from the sun and varying inversely with the square of the planet's distance from that body. Having made this discovery, he looked round for a force which acted under these conditions, and was capable of producing the observed results. It struck him, as we have seen, that the well-known force of gravitation might be the force required, and he saw that this force would be quite able to keep a projectile circling the earth if it started with the proper velocity, and the resistance of the atmosphere could be removed. He then proceeded to extend this calculation to the moon.

Why the Moon Circles the Earth. The moon is roughly distant from the earth by sixty radii of our planet. Therefore, if the law of gravitation is subject to the condition of varying as the inverse square of the distance, its intensity at the moon would be $\frac{1}{3600}$ of its intensity at the surface of the earth. Now experiment has shown that a body falling freely on the surface of the earth falls about 16 ft. in the first second. Therefore the moon ought to fall towards the earth at the rate of $\frac{16}{3600}$ ft. per second. Newton then calculated whether, if the moon fell constantly towards the earth at this rate, its known velocity would keep it in movement, and always at the same distance from the earth, like the projectile which we have been considering. His calculation apparently came out wrong, and he laid the whole question aside for sixteen years.

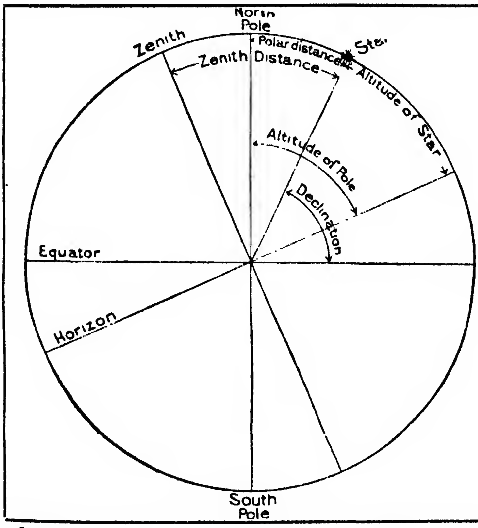
At the end of that time he discovered that his calculation had been based on an under-estimate of the size of the earth. He worked it out again with the improved data which were supplied by a new French measurement of the earth's circumference, and he thus found that the great question was solved. The fall of the moon towards the earth under the influence of gravitation was exactly sufficient, when compounded with its own velocity, to keep it moving for ever in its orbit. Newton at once devoted himself to this investigation, and finally produced the first coherent explanation of the planetary motions. They are all subject to the law of gravitation, which is thus enunciated:

Every particle of matter in the universe attracts every other particle of matter with a force proportional directly to the mass of each and inversely to the square of the distance between them.

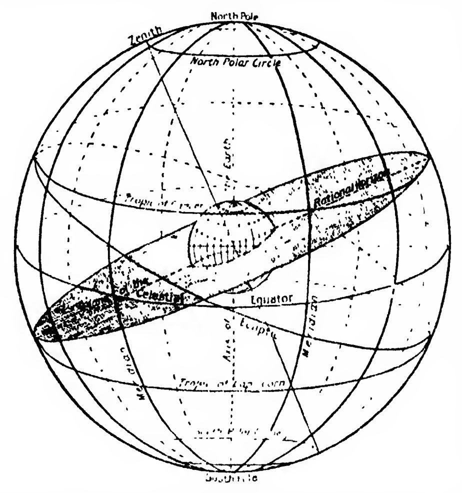
Universal Gravitation. So far as astronomers have been able to observe the behaviour of matter in the laboratory, in our own solar system, or in stellar systems situated so incredibly far away that the most powerful telescope is unable to show their components and light itself takes many years to bridge the abyss by which they are divided from the earth, this law has always been found to dominate material motions, and it is now the fundamental law of mathematical astronomy. It enables us to calculate the motions of all the bodies in the heavens, with the aid of a few observations of their positions at different times. In this manner tables of the movements of the moon and planets can be prepared for any length of time in advance. The "Nautical Almanac," which is indispensable to the navigator, contains such a set of tables for the whole year, and the chief business of Greenwich Observatory is to prepare this almanac for publication years in advance. We shall see elsewhere how these tables enable the sailor to find his way across the seas [see NAVIGATION]. The method by which they are calculated is very much more complicated than any we can explain here, since none of the planets moves under the simple influence of the sun's gravitation and its own velocity, but they are all *perturbed* by their mutual attraction, and complicated elements are thus introduced into the calculation of their future places.

Celestial Measurements. The determination of the places held at any particular time by the planets and the calculation of their orbit fall within the scope of mathematical astronomy. This it is quite impossible to teach in a brief course like the present, which merely aims at giving the student a rational idea of the mechanism of the heavens. But without any but the most elementary mathematics it is quite possible to give an outline of the principles which are involved in celestial measurements and computations.

In the first place it must be understood that the astronomer begins by dealing, not with real places of the planets and stars, but with their apparent projections on the celestial sphere. We are accustomed to talk in popular language of the "vault" of the heavens, the "arch" of



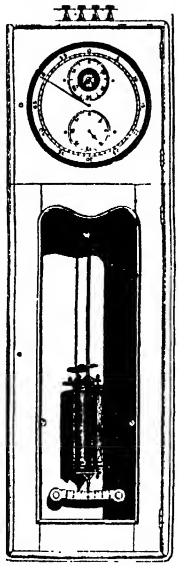
9. HOW CELESTIAL MEASUREMENTS ARE MADE



10. THE IMAGINARY CELESTIAL SPHERE

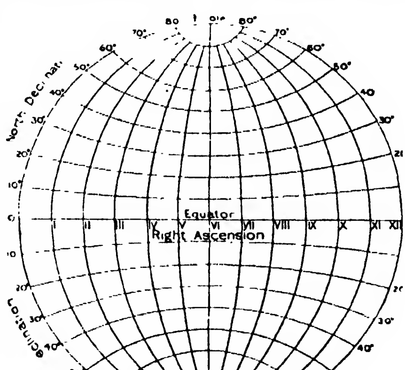
the sky, and so forth. From the earliest times man has had a notion that the earth was surrounded by a vast sphere on which the stars were fixed for his delight. The crystalline spheres of the early astronomers were but the development of this notion, which seems to come naturally to us as we look at the night sky.

As a matter of fact, we know nowadays that the stars are very far from being symmetrically arranged on the surface of a sphere which has the earth, or even the sun, in its centre. Instead of being equidistant from us, as that hypothesis would involve, some of them are hundreds of times farther away than others, and they are arranged in what, so far as we know at present, is an entirely irregular order. But ever since the dawn of astronomy it has been the custom to fix the places of both stars and planets with reference to this imaginary sphere. A little thought will make it clear that, if we ignore the question of the distances of the planets and stars from the earth, we can fix their places and trace their motions just as well if we deal with their projections on a vast imaginary sphere as if we dealt with the actual bodies themselves. This imaginary sphere is supposed to have the earth in its centre, and the regions into which it is mapped out for convenience of reference correspond with the divisions of terrestrial geography [10].



11. SIDEREAL CLOCK

Measurements on the Celestial Sphere. The pair of globes which used to form part of the furniture of every girls' boarding school have unfortunately gone out of use, and it is very rarely that an astronomical globe is nowadays seen. Yet a great deal of this part of astronomy can be learnt in five minutes by studying such a globe, which otherwise takes a long while to describe. The student may, however, take the ordinary geographical globe and apply to it all that we are saying about the imaginary sphere of the heavens. It is well known that the position of any place on the earth can be fixed absolutely by means of two, and only two, measurements. These are called in geography *latitude* and *longitude*. The former gives the angular distance of a town from the equator, and the latter its distance from a fixed meridian, which in English geography is that of the Royal Observatory at Greenwich. A moment's thought will make it clear that there can only be one place corresponding to any given latitude and longitude. Measurements of the apparent place of a star or planet are made in exactly the same way.



12. STELLAR MEASUREMENTS

The imaginary celestial sphere [10] is divided, like the geographical globe, by *great circles* or *meridians*, each of which passes through its two *poles*. These poles are situated where the axis of the earth, if indefinitely prolonged in both directions, would intersect the cele tial sphere, and so they occupy the *zenith* of the terrestrial poles—"zenith" being the astronomical term for the point vertically above the observer's standpoint. Every circle drawn on the celestial sphere which passes through its poles must be a great circle [see MATHEMATICS], which is the largest circle that can possibly be drawn on the surface of such a sphere; and all great circles are equal to one another. The celestial *equator* is a great circle drawn round the imaginary sphere midway between the poles, and it, of course, is situated where the plane of the earth's equator, if indefinitely prolonged, would intersect the celestial sphere [9].

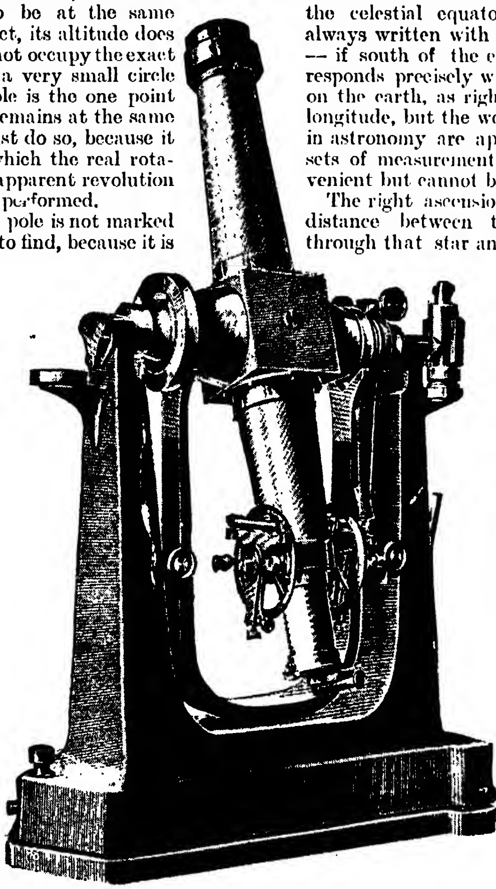
The Meridian. All these imaginary points and lines are definitely fixed in the sky with relation to the earth. But every place on the surface of the earth has its own celestial meridian, which is a great circle drawn on the celestial sphere through the poles and the horizontal points which lie due north and south of the observing station. The rotation of the earth causes this meridian to make a complete revolution of the sky in twenty-four hours. In the course of this revolution it passes over every visible star; but for convenience we usually speak of these stars as crossing the meridian, which we consider to be fixed as it appears to our senses, though, of course, this is only a way of speaking, and no astronomer forgets for a moment that the reality is just the reverse of the apparent fact. If we are going to set up an astronomical observatory, the first thing that we have to do is to determine the exact position of its proper meridian—or, in other words, to mark the point due south of it. The next thing is to determine its terrestrial latitude.

The latitude of a place on the earth is measured by the number of degrees between it and the equator. As the *quadrant*, or quarter of the great circle or meridian intercepted between the poles and the equator, measures 90°, we can, if we like, express the position of our station with equal accuracy by measuring its *polar distance*, which is obtained by subtracting the latitude from 90°; it is merely a question of convenience which measurement we use [9]. Bearing in mind that the celestial sphere is simply a reproduction of the terrestrial sphere on a larger scale, we shall see that the point on the celestial sphere which is the zenith of our standpoint has the same relation to the celestial pole and equator as the observing station has to the terrestrial ones. Talking of the zenith introduces us to another very important great circle on the celestial sphere—that of the *horizon*. The horizon, in popular language, is the limit of our vision at any particular place. But the astronomical horizon is more exactly defined as a great circle distant 90° from the zenith. If we are at sea, or on one of the flats of the Fen district, or a similar plain, the apparent

horizon and the astronomical horizon practically coincide.

Determining Celestial Altitudes. A glance at the diagram [9] will now bring out some interesting relations between these various points and circles on the celestial sphere. The *altitude* of any point in the heavens is measured by its distance in degrees from the horizon, and its *zenith distance* by the number of degrees between it and the zenith; the altitude, of course, can always be obtained by subtracting the zenith distance from 90°. When we are observing the altitude of any star, we usually find that it varies according to the time when we look at it. There is one exception to this rule, and that is the Pole Star, which seems to the naked eye always to be at the same altitude. As a matter of fact, its altitude does vary slightly, since it does not occupy the exact celestial pole, but makes a very small circle round it. The celestial pole is the one point in the sky which always remains at the same altitude. Evidently it must do so, because it is the end of the axis on which the real rotation of the earth and the apparent revolution of the celestial sphere are performed.

The actual north celestial pole is not marked by any star, but it is easy to find, because it is the centre of the circles which all the stars appear to describe in twenty-four hours. Its altitude is found in practice by measuring the latitude of any convenient circumpolar star when it crosses the meridian above and below the pole, and the average or *mean* of these two altitudes will obviously give the altitude of the pole. A glance at the diagram will make it clear that the altitude of the pole at any particular place must be exactly equal to the latitude of that place. Thus, at the north pole of the earth the altitude of the celestial pole is 90°; in other words, it coincides with the zenith; at the equator the altitude of the celestial pole is zero, and thus it lies on the horizon. As we go north from the equator the north celestial pole gradually comes into sight, and rises higher in the sky; at London its altitude is about 51½°.



13. PORTABLE TRANSIT TELESCOPE

Stellar Measurements. Two measures, as we have seen, are enough to fix a place on the earth's surface, and they will similarly fix the position of a star in the sky. There are various ways in which these measures may be taken. We might measure the *altitude* of a star at the moment when it crosses the meridian to the south of the pole, and the *time* at which it crosses the meridian. We might measure the distance of the star from the celestial equator, and its distance from any fixed point on that equator, and thus determine its celestial latitude and longitude. We might measure its distance from the zenith, or its altitude, and its distance from a fixed point on the horizon, which is known as its *azimuth* when measured from the south point.

This would be an inconvenient system, because such measurements would be continually changing with the diurnal rotation, whereas the angular distances of an object from the celestial pole and from a fixed point on the celestial equator are constant.

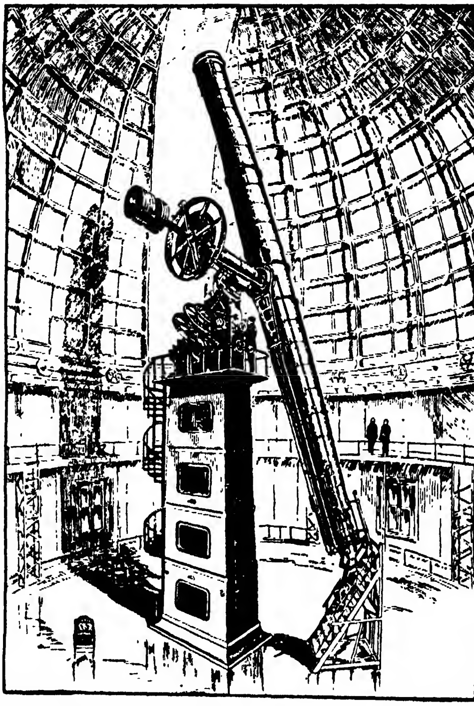
Right Ascension and Declination. The measurements by which an astronomer usually fixes the place of any star are known as its *declination* and its *right ascension* [12]. The declination of a star is its distance in degrees north or south of the celestial equator; for convenience it is always written with the sign + if north, and − if south of the equator. Declination corresponds precisely with the latitude of a place on the earth, as right ascension does with its longitude, but the words *latitude* and *longitude* in astronomy are applied to entirely different sets of measurements—which is rather inconvenient but cannot be helped.

The right ascension of a star is the angular distance between the great circle passing through that star and the pole, and another great circle passing through the pole and a fixed point on the celestial equator which is known as the vernal equinox. Right ascension is always reckoned from the equinox, which is zero, completely round the equator, which is divided into 360°. As the celestial sphere apparently makes one complete revolution in 24 hours, the meridian will pass over 15° of the celestial equator in every hour. It is usual, for convenience, to reckon right ascension not in degrees, but in hours, minutes and seconds. One hour is equal to 15°, one minute of time to 15 minutes of angular measurement, and one second of time to 15 seconds of angular measurement—thus expressed in symbols: 1 hr. = 15°, 1 min. = 15′, 1 sec. = 15″. As the position of a place on the earth is given by saying that it is situated in latitude 51° 30′, longitude 0°, so the position of a star like Sirius is given by saying that its right ascension is 6 h. 40 m. 12 sec., and its declination is 16° 35′.

There is used in practice a very convenient method of determining the right ascension of any star. If we know the time at which the imaginary point on the celestial equator known as the vernal equinox crosses the meridian of our observing station, and then observe the time at which the given star crosses that meridian, the interval of time between these two events will always give the right ascension of the star. Similarly the declination

of a star can easily be found by measuring its *north polar distance*, or the number of degrees which divide it from the north celestial pole. If this distance be less than 90°, the declination of the star is got by subtracting it from 90°; if it be greater, the declination is obtained by subtracting 90° from the north polar distance and prefixing a minus sign.

The Measurement of Time. Astronomy, as we have seen, introduces us to a measurement of time which differs somewhat from that in ordinary use. The ordinary day of twenty-four hours is simply the period in which the earth completes one revolution, as measured by the apparent movement of the sun. But since this motion is not quite uniform, the real solar day differs in length by nearly a minute at different times of the year. There is no such difference in the period of the earth's rotation, which is the most absolutely uniform measure of time that we know. We use consequently what is called *mean solar time*, which is a measure of this rotation. But we have already seen that the earth completes its apparent revolution in rather less than a day—to be exact, in 23 hours 56 minutes 4·09 seconds. This sidereal day is the interval of time which elapses between two successive passages of the same star across the meridian of a place. It is easy to understand the difference between the solar and the sidereal day when we notice that it amounts to exactly one day in a year. The sidereal day is measured by the rotation period of the earth. But the earth not merely rotates, it also revolves round the sun in a yearly orbit. In the course of this revolution it completes one additional rotation on its own axis. Therefore the earth makes only about 365¼ rotations in a year with regard to the sun, whilst it makes 366¼ with regard to the stars. This is why the sidereal day is shorter than the solar day by about $\frac{1}{366}$ part.

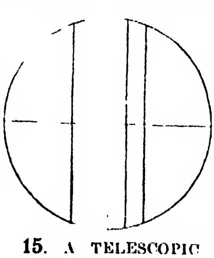


14. MODERN EQUATORIAL TELESCOPE

The Astronomer's Clock. One of the most essential pieces of apparatus in an observatory is a clock set to keep sidereal—not solar—time, and so regulated that it points to 0 h. 0 m. 0 secs. at the moment when the vernal equinox crosses the meridian. This clock [11] is always divided into twenty-four hours, to avoid the inconvenience of having to say morning or afternoon. For the same reason astronomers divide the solar day into twenty-four hours, beginning at noon so that the hours after midnight are known as 13, 14 etc. With the aid of this clock the right ascension of any star can be immediately found by observing the instant at which it crosses the meridian; the hour then shown on the sidereal clock will give its right ascension.

The Ecliptic. There is one other great circle of the celestial sphere which is of importance. This is the ecliptic, or great circle in which the sun appears to travel [see **10**]. It is really, of course, the circle in which the plane of the earth's orbit intersects the celestial sphere. The poles of the ecliptic are the two points 90° distant from it. The ancient astronomers usually defined the places of the heavenly bodies by their celestial *latitude* and *longitude*, measured respectively north or south of the ecliptic, and along the ecliptic from the vernal equinox. These measurements have nowadays given place to the more convenient system of right ascension and declination.

The Transit Telescope. We now come to consider the instruments by means of which astronomers measure the position of the stars and planets. The telescope is an essential adjunct to this work, but it is not used in this instance to magnify the celestial object, as is the case in other branches of astronomical work, but simply to define its position with the greatest possible accuracy. Before the telescope was invented astronomers could only determine the apparent position of a star by pointing a straightedge to it as nearly as possible. They achieved a wonderful degree of accuracy with the instruments made on this principle, but it was only the invention of the telescope which rendered possible the achievements of modern astronomy. The telescope is now used by astronomers in exactly the same way as the surveyor uses the theodolite—in order to give precision in getting the exact direction of the object. The field of the telescope used for this purpose is divided into a number of parts by the finest possible threads of spider's web, which are arranged so that two of them intersect in the exact centre of the field [15]. When the image of the star or planet is made exactly to coincide with this intersection, we are sure that the telescope is pointing absolutely to its apparent place.



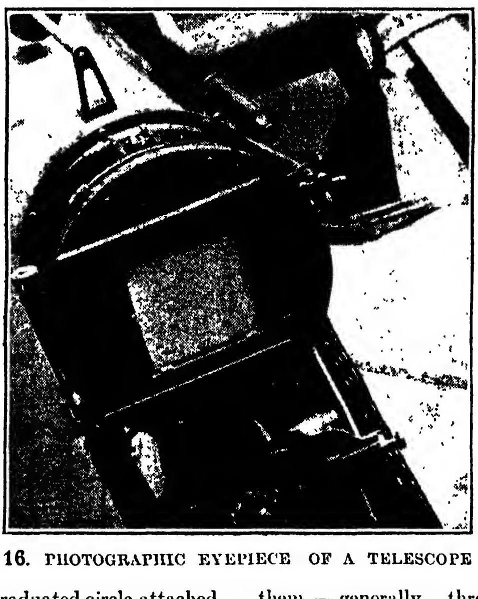
15. A TELESCOPIC FIELD

The *transit instrument* [**13**], which is the one chiefly used for the determination of stellar places, consists of such a telescope with a lens 10 in. or 12 in. in diameter. It is fixed up on the diameter of a large circle, known as the *transit circle*, whose circumference is divided into 360° and their fractions. This transit instrument is set up in the observatory so that the plane of its circle coincides with the plane of the meridian. The telescope is mounted on a horizontal

axis, so that it is free to swing up and down in this vertical plane, but cannot move out of it. The central thread in its field is so adjusted that it precisely coincides with the meridian, however the instrument may be turned on its axis. The greatest precautions are taken to insure absolute rigidity in the mounting of a transit instrument, which is usually placed on a very massive block of masonry so as not to be affected by local tremors of the earth.

Finding Stellar Places. When it is desired to observe the meridian passage of a star, the telescope is turned by means of the graduated circle to the known altitude at which the star culminates. The sidereal clock stands also beside the transit instrument, beating seconds very audibly. When the star is almost due, the observer begins to count the seconds from the beginning of the last minute. As it flashes into the field of his telescope, and hastens across the threads, he estimates the exact moment at which it crosses each of them, usually five or seven in number, and by taking the average of all these readings he gets the precise instant at which the star has crossed the central thread, or the meridian. In modern practice the electric chronograph is called to the astronomer's assistance, and by merely pressing a button as the star crosses each wire the time is registered with greater accuracy than was possible under the old method. The time of meridian passage, when various minute corrections for the error of the clock, the observer's personal equation, and so forth have been applied to it, gives the right ascension of that star.

The transit instrument can also be used to measure the declination of a star. As a matter of convenience, what is measured is not the star's actual declination, but its zenith distance. The field of the telescope contains a horizontal spider line [**15** AB] as well as the vertical ones used in recording transits. This line is movable by a screw. When the star whose declination it is desired to observe is approaching the meridian, the telescope of the transit instrument is pointed as nearly as possible to its place, and as the star rushes across the field of the telescope this horizontal line is adjusted so that it bisects the image of the star just as it crosses the meridian. By means of the graduated circle attached to the telescope the angular distance between the star and the zenith can then be measured accurately, and if we know the latitude of the observing place it is a simple calculation to find the star's declination [**15**]. There are many other forms of instrument, all consisting of a telescope in conjunction with some means of measuring its changes in direction, which will be found fully described in such a textbook as Mr. G. F. Chambers's "Astronomy."



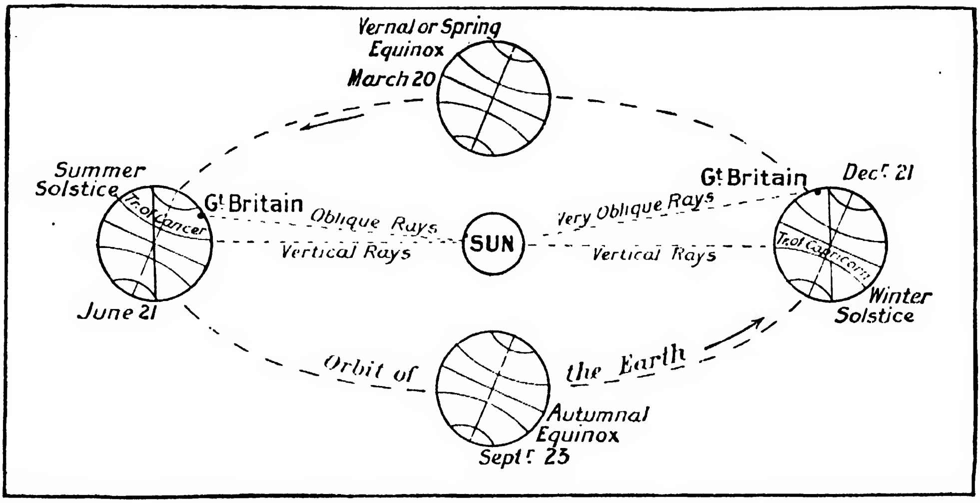
16. PHOTOGRAPHIC EYEPIECE OF A TELESCOPE

The Telescope. The telescope is an essential part of most astronomical instruments, and must be briefly described, though for fuller details the student is recommended to consult the course on OPTICS and page 6126. The telescope has two functions in astronomy. One is to enlarge celestial objects by collecting into one focus the rays received on its lens or mirror. The other is to ascertain the exact place of a stellar object by enabling us to be sure that our instrument is pointed exactly towards it. The former function of the telescope is chiefly employed in studying the moon, sun, and planets, and the latter in studying the stars. Telescopes are of two kinds, *reflecting* and *refracting*. The former brings the rays of light to a focus by means of a concave mirror, the latter by means of a convex lens. Galileo's original telescope was a refractor, and the most powerful modern telescopes are built on these lines.

The Achromatic Refracting Telescope. The reflecting telescope was introduced by Sir Isaac Newton on account of the great difficulty which existed in his day in obtaining large discs of glass sufficiently pure and homogeneous to form the lenses of large telescopes. This difficulty has now been practically overcome, and lenses as large as 4 ft. in diameter can be constructed with great accuracy. The lens, however, has an essential imperfection from which the concave mirror is free. Ordinary light consists of a great many rays of different colours and of different degrees of refrangibility. The concave mirror brings these all to a focus at the same point, whereas the glass lens does not, and consequently the early refracting telescopes gave blurred images, which became less distinct as the lenses were made larger, and the distances through which the different rays were deflected increased.

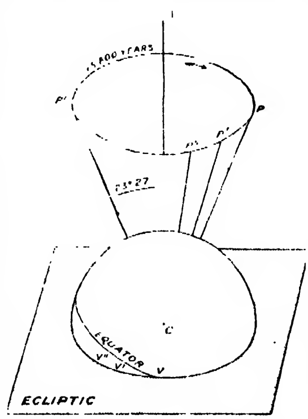
This difficulty has been largely obviated since Dollond's discovery of the *achromatic lens*, which is made up of two lenses of different kinds of glass. The modern refracting telescopes give images almost as clear as the reflecting telescopes, and they have practically superseded the latter. For all purposes of mathematical astronomy, which deals with the motion of the planets and stars, little or nothing is gained by increasing the size of the telescope beyond 10 in. or 12 in. in aperture. The gigantic telescopes [**14**] which are made nowadays for such observatories as can afford them — generally through the munificence of millionaires like Mr. Lick and Mr. Yerkes—are designed for the use of the physical astronomer, who endeavours to find out the conditions which exist on the surface of the various planets, and to discover the constitution of the sun and its brother stars.

Photography and the Telescope. Nowadays the photographic camera is largely used in conjunction with the telescope as a supplement to the eye of an observer. The photographic plate is capable of recording impressions which are far too faint and illusive to be recorded by the human



17. EQUINOXES AND SOLSTICES AND THE ECLIPTIC

eye. If one gazes very long at the same object the eye grows fatigued, whereas the photographic plate never wearies and continues to accumulate information from the successive rays of light which are allowed to reach it, often for many hours at a time. In this way a great many new celestial facts have been discovered, such as the existence of the vast nebula which envelops the Pleiades, and is quite beyond the reach of the most powerful telescope in the hands of a human observer. The light rays which have most effect upon the photographic plate are almost invisible to the eye, and, consequently, special photographic telescopes are now made with the lenses so curved that these actinic rays are brought by them to an exact focus in preference to the rays of longer wave length by which normal vision is conducted. The latest survey of the heavens has been made by means of a number of similar photographic telescopes [**16**], erected at observatories in all parts of the world, which have succeeded in charting something like thirty million stars.



18. THE PRECESSION OF THE EQUINOXES

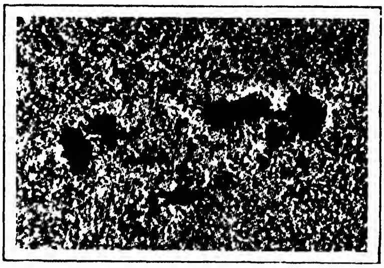
The Spectroscope. After the telescope, the instrument which is of greatest value to the modern astronomer is the spectroscope. It is by means of this marvellous instrument that we have been enabled to analyse the constitution of the sun and the far-off stars, and to satisfy ourselves that the universe is everywhere composed mainly of the same chemical elements which are found upon the earth. In its simplest form it consists merely of a telescope and a prism. Newton discovered more than 200 years ago that when ordinary sunlight was passed through a glass prism it was split up into a band of colours [see Frontispiece opposite page 6097], gradually shading off from red at one end through orange and yellow and green to violet at the other. For a fuller explanation of this fact the course on OPTICS must be consulted; it is enough to say here that it means that light consists of vibrations or waves in the ubiquitous ether, which vary merely in length. Light of one particular wave-length is always associated with the sensation of a particular colour when it falls upon our eyes, and white light is a mixture of a great number of rays of all possible wave-lengths. The action of the spectroscope is simply to analyse the light which falls upon it from a distant object into a regular series of wave-lengths, each of which is recognisable by its particular colour and also by its place in the *spectrum*, as the colour band shown by the prism is called.

Spectrum Analysis. The first great step in spectroscopic analysis was taken when Kirchhoff and Bunsen discovered, in the early part of the last century, that a heated gas gave out light rays of the same wave length as those which it absorbed when ordinary white light was passed through it. White or solar light is made up of rays of very various wave-lengths. But these do not form a continuous series. When we examine this solar light with the aid of a spectroscope, we see that the long band of variously coloured light, into which it is drawn out by the train of prisms, is crossed from end to end by a series of dark lines, varying in width. Each of these dark lines, of course, is simply the negation of light at this particular place in the spectrum. Something between us and the luminous body of the sun has stopped the ray of light whose wave length would make it visible at the particular spot in the spectrum where a dark line occurs.

If we apply the spectroscope to analyse the kind of light which we produce in the laboratory by heating some element until it becomes incandescent, we find that we get an entirely different kind of spectrum, which consists of a few bright lines. If a piece of sodium is held in the flame of a Bunsen burner, and looked at through the spectroscope, we see a few bright yellow lines, whereas, when iron is similarly treated, the spectrum consists of several hundred bright lines.

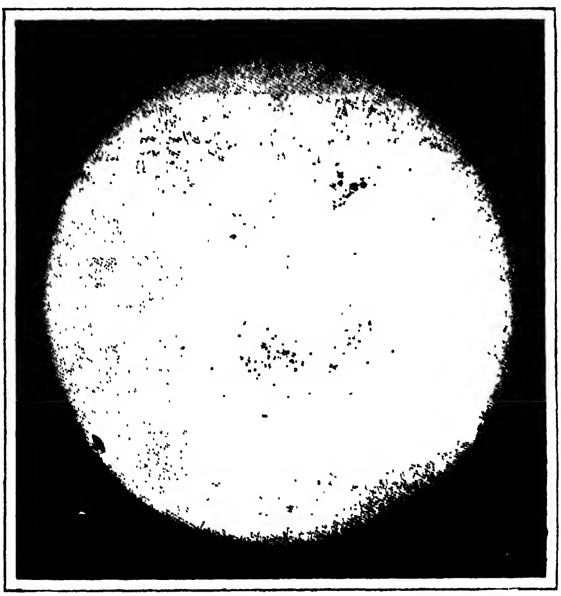
It is further found by experiment that the same element, when reduced to the condition of incandescent gas, invariably makes its presence known by the appearance of the same series of bright lines. Consequently, the spectroscope affords a simple and conclusive test of the presence of any particular element in a body which is hot enough to be reduced to the condition of an incandescent gas.

This is the physical state of all the visible stars, and the reader will now begin to see how it is possible for us to detect the chemical constitution of such stars. When we turn the spectroscope upon a star, though it be so far away that its light may have taken hundreds of years to reach us, and see the bright lines which characterise the spectrum of hydrogen blazing out in their unmistakable positions, we say at once that the atmosphere of that star must consist of white-hot hydrogen, and so on with all the other elements which have been discovered as existing in stars.



19. SUN-SPOTS AND GRANULATION OF SUN'S SURFACE
(Photographed at Meudon Observatory by M. Janssen. From "Knowledge")

Selective Absorption. But the discovery of what is called *selective absorption* by Kirchhoff and Bunsen carries us a step further. When a white-hot solid body is examined with the spectroscope, it invariably gives what is known as a continuous spectrum, in which there are no dark lines, but the colour shades off uniformly from one end to the other. The spectrum of the sun and many of the stars is of this character, with the addition of the numerous dark lines which have already been mentioned. Kirchhoff and Bunsen discovered by experiment that if light from an incandescent solid body were passed through a volume of gas, that gas absorbed exactly the same kind of light which it would emit if it were hot enough to shine by its own light. Consequently, if we find that the spectrum of a particular star is a continuous spectrum crossed by a series of dark lines which correspond in number and position to the bright lines which form the spectrum of incandescent hydrogen, we can say at once that the star consists of a glowing solid body encompassed by an atmosphere of hydrogen.



20. PHOTOGRAPH OF THE SUN, OCT. 22ND., 1905
(By E. W. Barlow, F.R.A.S., from "Knowledge")

As a rule, stellar spectra are much more complicated than this simple example, and we find in such spectra dark lines which prove the existence of a large number of elements in the atmospheres of these remote orbs. It will now be seen how the spectroscope is able to tell us of what elements the stars are composed. Its use affords the basis for a very important branch of astronomy known as astrophysics, and some of the facts deduced from it will be explained later.

The Equatorial Telescope. The large telescopes which are used for studying the physical condition of the stars and planets are mounted in a peculiar fashion which must here be explained. We have seen that the telescopes used for measuring the position of the stars are mounted in such a way that the star to which they are pointed appears to rush rapidly across their field, and only a fleeting glimpse can be had of it. This, of course, is due to the fact that the telescope shares the earth's rotation. But when it is desired to watch a star or planet through the greater part of a night, it is necessary to have some method of keeping it constantly in the field of the telescope. The larger the telescope the more does it exaggerate the apparent motion of the star, and to continue to move it by hand so as to keep the star in its field of vision would be quite impossible in the case of the huge telescopes with which the most important work of this kind is done. This difficulty is obviated by what is called an *equatorial* mounting [14]. The essential part of this is an axis pointing with great accuracy towards the celestial north pole, and borne on the top of a solid pier of masonry: this is known as the polar axis. Through a socket on the end of this axis passes another axis at right angles to it, known as the declination axis.

The telescope is rigidly attached to the upper end of the declination axis, and balanced by a weight at its other end, so that it has no tendency to turn round on the polar axis. The polar axis is attached to a system of clockwork which makes it turn slowly round from east to west at the rate of one revolution in twenty-four hours. As the earth completes a revolution from west to east in the same period, the one movement exactly neutralises the other, and if the telescope be pointed at any celestial object, by turning it on the declination axis it will continue to follow that object so long as the clockwork is kept in motion.

All that the observer has to do, when he has once fixed his telescope in the proper direction, is to move from time to time so as to keep his eye at the eyepiece of the telescope, which appears, of course, to be revolving with regard to him. It is with these two instruments—the transit circle and the equatorial telescope, supplemented by the spectroscope and the camera when necessary—that by far the greater part of modern astronomical research is carried out. The transit circle provides the data for mathematical or descriptive astronomy, and the equatorial, with the spectroscope and camera, provide the data for physical astronomy.

We shall now pass on to a general account of the solar system, as its mechanism and constitution have been revealed by the use of such instruments.

The Solar System. The solar system consists of a central star, the sun, round which there revolve eight major planets with their satellites, a swarm of nearly six hundred minor planets or asteroids, and an unknown number of comets and meteorites. The planets are divided for convenience into two groups of four each. The inner planets in order are Mercury, Venus, Earth, and Mars; the outer planets are Jupiter, Saturn, Uranus, and Neptune. The minor planets, with only one exception yet known, occupy the space between Mars and Jupiter. The only planets which have no known satellites are Mercury and Venus; Earth has one—familiar to us all as the moon; Mars has two; Jupiter, seven; Saturn, ten; Uranus, four; and Neptune, one. All the planets move round the sun in elliptical orbits, which are not very far from being circular, whereas the comets and meteorites move in extremely eccentric orbits, some of which are strongly suspected not to be ellipses at all, but hyperbolic curves which carry them away for ever into space after a visit to the sun. The following table shows the diameters, masses, distances from the sun, and periodical times of the eight major planets.

Planet.	Diameter in miles.	Mass (Earth = 1).	Mean Solar distance in millions of miles.	Periodical time in years.
Mercury ..	3,030	0·047	36·0	0·24
Venus	7,700	0·82	67·2	0·62
Earth	7,917·6	1·0	92·9	1·0
Mars	4,230	0·107	141·5	1·88
Jupiter ..	86,500	317·7	483·3	11·86
Saturn.. ..	73,000	94·8	886·0	29·46
Uranus ..	31,900	14·6	1,781·9	84·02
Neptune ..	34,800	17·0	2,791·6	164·78

The Immensity of the Sun. The great luminary which warms, lights and rules the solar system is, like the majority of its fellow stars, a gigantic bubble. In other words, it is a globe of glowing gas, which is nowhere solid, though the immense pressure which must exist in its interior probably causes this gas to assume there a density greater than that of any solid which we know. The sun appears to human vision as a brilliant globe of a little more than half a degree in diameter. It is about the same apparent size as the moon, since the size of the sun is to that of the moon very nearly in the same proportion as their relative distances from the earth. In reality, however, the sun is a gigantic orb, so huge that if the earth were at its centre the whole orbit of the moon would lie well within its circumference. The diameter of the sun is about 866,500 miles. If the sun were represented by a globe 2 ft. in diameter, the earth on the same scale would be the size of a large pea, less than a quarter of an inch in diameter.

The mass of the sun is about 332,000 times that of the earth, but its specific gravity is only about a quarter that of the earth—1·41 if that of water be taken as unity. The mean distance of the sun from the earth is about 92,900,000 miles; but as the earth's orbit is not circular but elliptic, this distance varies by about 3,000,000 miles, being smallest in January, and greatest in July.

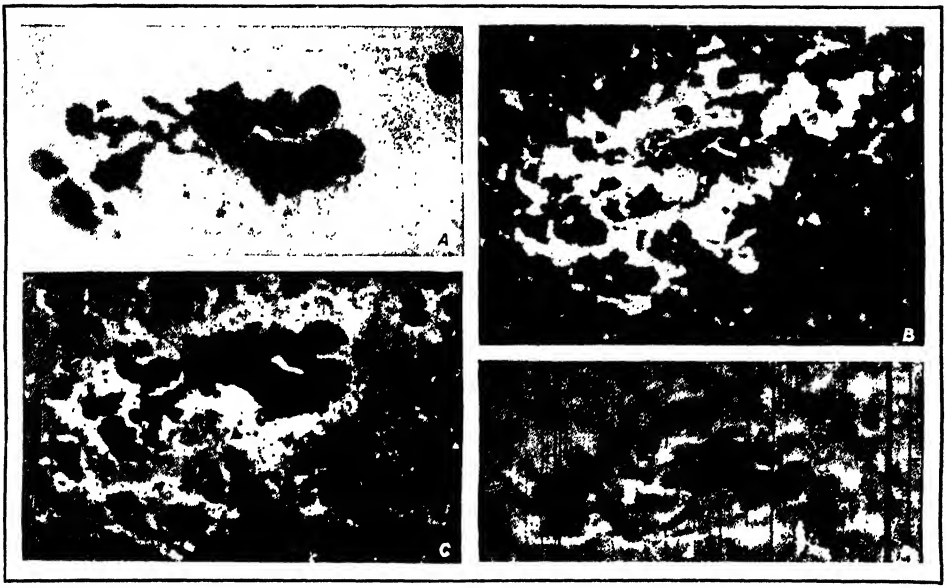
Solar Movements. The sun rotates on its own axis just like the earth, as has been discovered from the fact that the spots on its surface invariably cross its disc from east to west. It completes a rotation in 25¼ days. The apparent period of the sun's rotation as seen from the earth, however, is 27¼ days—the difference being due to the fact that the earth is constantly moving round the sun in the same direction in which the latter rotates.

The sun appears to move round the earth in a plane which is inclined to the plane of the earth's equator at an angle of about 23½°. This plane is known as the plane of the *ecliptic*, from the fact that eclipses only happen when the moon is crossing it, and the angle which it makes with the plane of the equator is called the *obliquity* of the ecliptic. This angle is obviously equal to the sun's maximum declination, or distance from the celestial equator in June and December, at which times the sun is respectively north and south of that equator as viewed from our latitudes. The two opposite points in which the great circle of the ecliptic crosses that of the celestial equator are known as the *equinoxes*, because when the sun passes these points on March 21st and September 21st, day and night are equal in length. The two points in the ecliptic which are equidistant from the equinoxes are called the *solstice*, because when it reaches them on June 21st and December 21st, the sun appears momentarily to stand still, and thereafter reverses its motion in declination [**17**]. The plane of the ecliptic is really the plane of the earth's orbit.

Precession of the Equinoxes. It has been known for more than two thousand years that the equinoxes do not remain constantly at the same point in the ecliptic, but that they are slowly moving westward along it. They complete the circle in about 25,800 years, so that since Hipparchus discovered this movement in 125 B.C., about one-twelfth of it has been described. Consequently, as we shall see directly, the Zodiacal signs no longer correspond to the constellations after which they were named three thousand years ago, but each of them has drifted into the next constellation. This movement, known as the *precession of the equinoxes*, is due to the fact that the earth's axis does not remain strictly parallel to itself, but travels round the outside of a cone, just like the axis of a sleeping top [**18**]. Consequently the plane of the earth's equator, and of the celestial equator, is continually changing; and, as the equinoxes are simply the points at which the equator intersects the ecliptic, they must change too. One result of this is that the celestial poles are also changing; they move in small circles round the poles of the ecliptic.

The present Pole Star happens to be close to the celestial north pole; but in the lapse of many centuries the latter will move away from it, and other stars will be known as Pole Stars. About 14,800 A.D., the brilliant Vega will be sufficiently near the Pole to become the Pole Star.

The Zodiac. The belt of the sky which occupies 8° on each side of the ecliptic is called the *zodiac*, and it is within this belt that the moon and the chief planets confine their movements, since none



21. THE GREAT SUN-SPOT OF 1903, OCTOBER 9

A. The Spot photographed at Greenwich B. and C. Calcium flocculi at different levels D. Hydrogen flocculi (From "Knowledge")

of their orbits is inclined to that of the earth by more than 8°. The Zodiac, which circles the celestial sphere, is divided into twelve signs, each of which occupies 30°, and roughly coincides with a constellation. The following lists give the *signs of the Zodiac*, with the seasons in which the sun passes through each of them:

Spring: Aries the Ram; Taurus the Bull; Gemini the Twins.

Summer: Cancer the Crab; Leo the Lion; Virgo the Virgin.

Autumn: Libra the Balance; Scorpio the Scorpion; Sagittarius the Archer.

Winter: Capricornus the Goat; Aquarius the Water-bearer; Pisces the Fishes.

Owing to the precession of the equinoxes, the signs of the Zodiac do not now correspond with the constellations of which they bear the names. Thus the sign Aries, in which the sun is seen on March 21st as it passes the vernal equinox, with which the solar year begins, is now in the constellation of Pisces, and in the course of the next 23,000 years it will move steadily backward through the constellations until it returns to the Ram, where it stood when its name was first given to it.

The Sun's Photosphere. The bright visible surface of the sun is known as the *photosphere* [**20**], or sphere of light. It probably consists of a vast sheet of incandescent clouds floating in a less luminous atmosphere, and it is intensely brilliant for the same reason as the mantle of an incandescent gas burner, because of the intense temperature to which it is raised. It is not easy to estimate the actual brightness of this photosphere, but the most powerful electric light which we are able to produce looks absolutely black when projected against it. The temperature of the photosphere cannot be measured with any exactness, but it is certainly greater than any which we can attain on the earth, being at least 6,000° C. The temperature of the sun's interior must undoubtedly be very much higher than that of its surface. The photosphere examined through a telescope is not homogeneous, but consists of a darker background, sprinkled over with *rice grains* or *granules*, which are much more brilliant [**19**]. The rice grains are usually about 500 miles in length, but here and there are drawn out into long streaks known as *filaments* or *willow leaves*. The surface of the sun is mottled here and there with brighter specks and patches called *faculæ*.

Sun-spots. The most interesting fact about the photosphere is the existence in it of *sun-spots*, which vary greatly in size, number, and duration [**19**, **20**, and **21**]. Sometimes these spots are exceedingly numerous, so that hardly any part of the equatorial belt of the sun is free from them; at other times, hardly one is to be seen. Some of them seem to appear and disappear again within the space of two or three days; others persist for months at a time, and it is by means of these persistent spots that the periods of the sun's rotation has been measured. The smallest spots visible through our telescopes are only about 500 miles in diameter, whilst the largest may be seven or eight times as big as the earth. A typical spot consists of a central part, called the *nucleus*, surrounded by a border, the *penumbra*, which is intermediate between the dark centre and the surrounding brilliance of the photosphere [**21**]. The penumbra surrounding a group of spots has been known to be as much as 150,000 miles in diameter, and spots of this size can be seen with the naked eye, when the sun is viewed through a cloud or piece of smoked glass.

The real nature of sun-spots is still disputed, but there is little doubt that they are something of the nature of whirlpools or storms in the photosphere. It has been discovered from a long series of observations that the number of spots visible on the surface of the sun varies through a period of about 11 years. 1905 was a year of sun-spot maximum, and in 1912 the number of sun-spots will probably have sunk to a minimum, rising again to a maximum about 1916.

Various attempts have been made to trace the influence of the spot cycle on terrestrial meteorology. There is little doubt that it has some influence of this kind, because the development of a large sun-spot is invariably accompanied by electrical disturbances on the earth. It is practically certain that the appearance of a large number of sun-spots on the sun's photosphere indicates that the sun is in a condition of abnormal activity, but we can hardly go further than that yet.

The Chromosphere and Prominences. Above the photosphere of the sun lies an atmosphere called the *chromosphere*, which is probably about 10,000 or 12,000 miles in thickness. This "sphere of colour" is so called because it is of a brilliant scarlet hue. We do not usually perceive it, because its light is usually drowned in the intense radiance of the photosphere. But on the rare occasions when the sun is eclipsed by the passage of the moon between it and the earth, this scarlet chromosphere suddenly flashes into sight when the photosphere is hidden. The spectroscope shows that it is chiefly composed of incandescent hydrogen, mingled with helium and calcium vapour.

The lower portion of the chromosphere is known as the *reversing layer*, because when the spectroscope is turned upon it during an eclipse at the moment of totality, all the dark lines which usually cross the solar spectrum suddenly flash out in brilliant colour against a dark background. This means, as we have already seen, that these dark lines are due to the absorption of light, of the wave lengths corresponding to each of them, by the lower portion of the chromosphere. It is from these lines that we deduce the existence of a large number of terrestrial elements in the sun, of which the most important are hydrogen, helium, carbon, iron, copper, silver, tin, lead, sodium, potassium, silicon, zinc, calcium, magnesium, aluminium, possibly oxygen, and a number of less common metals. There is good reason to suppose that all the other terrestrial elements are present in the sun, but as yet their existence has not been established. It is possible that some of them are not really elements, and are dissociated by the intense heat of the solar atmosphere.

When the sun is obscured during an eclipse, a number of fiery scarlet clouds or *prominences* [see Frontispiece opposite page 6241] are seen projecting from its edge. Since 1868, when the spectroscope was first turned upon these objects, it has been known that they are clouds or jets of incandescent gas, chiefly hydrogen and helium. They have been known to rise as much as 400,000 miles from the sun's surface, with a velocity which may be as great as 250 miles per second. These prominences can be seen actually springing up and changing form, and a very ingenious adaptation of the spectroscope, which we owe to Lockyer and Janssen, enables us to study them even when they are quite invisible to the eye.

The Corona. The outermost appendage of the sun is the *corona*. It has been known from very remote antiquity as a wonderful halo or crown of light which surrounds the sun at the moment of eclipse but is quite invisible at other times, even to the eyes of science, though there is reason to believe that before very long we may be able to study it also at any time that we choose. Its nature is not yet fully understood, though we believe that it is some kind of extremely tenuous atmosphere which stretches out for millions of miles from the solar surface. It varies greatly in form from eclipse to eclipse, and its changes appear to be in some way connected with the number of spots visible on the sun. The spectroscope shows that it consists of glowing gas, chiefly *coronium*, but its extreme rarity is proved by the fact that comets have passed right through it, as in 1882, without any apparent checking of their motion. There is good reason to suppose that its luminosity may be an electrical phenomenon, somewhat analogous to the Aurora Borealis.

The Heat and Energy of the Sun. The sun has two great functions in our system. The first is, as we have seen, to keep the planets moving in their orbits by the power of its gravitational pull. The second is to supply heat and light to those planets. As far as the earth is concerned, there can be no question that the existence of life is made possible entirely by the radiations which reach us from the sun. If it were not for them, the earth would be a sterile globe, with a temperature approaching absolute zero, on which not only the water, but even the air would be frozen solid. The quantity of heat which the earth receives from the sun in a year is sufficient to melt a sheet of ice 200 ft. thick over the earth's whole surface. Every square foot of the earth receives annually enough energy from the sun to raise a weight of 100 tons to the height of a mile. As the sun is radiating heat in all directions alike, it is calculated that it must be giving out continuous energy equal to nearly 120-horse power for every square yard of its surface. How is this immense output of energy kept up? We know from the geological record that it has been going on, at the very least, for 10,000,000 years, and there is no visible sign of its diminution. The old notions that the sun derived its heat from any form of combustion, or that it was merely an intensely hot body which was gradually cooling off, are quite inadequate to account for this marvellous expenditure of energy.

When the Sun will Solidify. The true explanation is undoubtedly that given by Helmholtz and Lord Kelvin, that the sun is a gaseous globe which is continually shrinking as it loses heat. It is not possible to explain within our limits why this shrinkage should keep up the sun's temperature, but it is physically certain that it would do so, just as the fall of a clock weight or the head of water in a reservoir has the power of doing work [see page 315]. The shrinkage of the sun means that its outer parts are steadily falling towards the centre, and in this process they give out sufficient energy to keep up the solar radiation. An annual shrinkage of 300 ft. in the solar diameter is amply sufficient to supply this energy which the sun gives out as heat and light. There is no doubt that such a shrinkage is actually taking place. As yet, it is impossible to apply the test of measurement, since it would need about 10,000 years for the resultant change in the sun's diameter to be perceptible to our most accurate micrometer.

The time will undoubtedly come in the history of the sun, as it has already come in that of the inner planets, at which its surface will begin to solidify, and from that moment its emission of heat and light will begin very seriously to diminish. But at the most moderate computation that time is at least 5,000,000 years ahead of us, and we need not be seriously alarmed about this particular form of the Day of Judgment.

Continued

PHILOSOPHY & ITS PROBLEMS

The Desire of Philosophy is to get "to the bottom of things." Truth and Knowledge. Scepticism. Agnosticism. Materialism. Is Mind an Accident of Matter?

Following [illegible] from page 6101

By Dr. C. W. SALEEBY

PHILOSOPHY is a great and noble word, which means the *love of wisdom.* In the primitive sense there are none but the basest few who may not humbly call themselves philosophers.

But, of course, we know that the term philosophy is now employed in a special sense. It is used in order to indicate a special department of knowledge or inquiry, and it is this department which we must first of all seek to define. Biology is concerned with life, astronomy with the stars. What is philosophy concerned with?

Now, it is certainly true that there have been professional philosophers whose works from first to last have amounted to nothing more than mere word-jugglery or verbal gymnastics. Their books may have an elegant appearance, they may be apparently intelligible or apparently unintelligible: but in the upshot, as other writers soon show, there has been nothing said about anything whatever, except merely *words.* It is not by the word-jugglers however, that philosophy must be judged. Its proper subject-matter is not words but realities of some kind: and the business of man's mind is with realities—urgently and necessarily.

The Problem of Philosophy is the Nature of Reality. Indeed it is just precisely the nature of reality that philosophy is concerned with. Phrased in popular language, its desire is to get to the bottom of things. Looking around him, man finds many appearances—"stars and street mud," plants and children—whilst he is, at the same time, conscious of his own self, to which all that is outside it appears. What, then, he asks himself, amidst all this diversity and change and magnitude—what is the inner nature of all these things, or of whatever they represent or are produced by? The problem of philosophy, then, is the *nature of reality* or the *nature of being.*

In comparatively recent times a special word, which may be novel but is not difficult, has been invented in order to do away with the former confusion of names, and that word is *ontology*—which simply means the science of being. It was high time to introduce such a word, because what with such terms as philosophy, metaphysics, logic, epistemology, and a host besides, confusion was becoming worse confounded; and it is confusion that is the pre-eminent danger of the philosopher. At least one of these words must, however, be noted here, and that is the word metaphysics. Metaphysics is a famous old name of scarcely less antiquity than philosophy itself. It was apparently coined by the followers of Aristotle, the greatest pupil of Plato, who was the greatest pupil of Socrates, as a general term for the subject-matter of the treatise which their master composed after his "Physics." Metaphysics simply means *after physics.* Evidently there is no particular virtue in the term, which explains nothing, and may be and has been defined in many very varying senses—including, for instance, what we now mean by "logic." At the present day, however, the best rule to make is to leave the word out of one's vocabulary altogether. So far as the search for truth is concerned, it is of much less than no use at all.

The Question at the Root of all Philosophies. We shall content ourselves for the present, then, with the use of the famous old word, in its best recognised meaning of the search for reality, or we may define it as the quest of truth—meaning by that not merely the practical truth concerning the facts around us, but the ultimate or final truth of those facts and of the facts of mind. But, pray, what is the distinction between the practical kind of truths on which we daily act, and ultimate truth or absolute truth? In what sense can anything be more true, more thoroughly true, than the ordinary facts which we observe in the behaviour of matter around us? This simple and very pertinent question is at the root of all philosophies whatever, and we must do our best to answer it. There is a well-recognised name, indeed, for the doctrine which asserts that truth, as we think we know it, is absolute truth, and that things are what they seem. We may call this doctrine crude realism.

Beyond all question this is the oldest of all philosophies. It is the unformulated philosophy of a child, and, indeed, of anyone who has never thought about the subject. To a child, or to such a man, there can be nothing more real than the reality of—let us say—a chair. It is a thing that can be seen and felt, and "seeing is believing." A chair is plainly a chunk of reality. Things are as they appear to us; there is no more of them than appears to us: and what we see is simply what is there to see. Mind is conceived as a thin sort of matter, and the question of the relation between mind and matter is never asked.

"Chaotism." On this view in its earliest form man lives in a chaos; all around him is infinite multiplicity and variety, which cannot be resolved into anything more simple. As to any relations that may exist between the mind or minds to which these objects are presented and the objects themselves, crude realism asks no questions.

But, as we may readily believe, this earliest of stages is very soon passed. However various the facts of Nature, it very soon becomes evident that there is at least some degree of relation between them. An unsupported stone falls not once or twice only, but always. The sequence of day and night and of the seasons,

the apparent movement of the sun, the growth of crops—these all display some degree of order and hints of interdependence. So unmistakable is this that it had to be recognised long before the birth of science, the business of which is to discuss the relations between the phenomena of Nature; so salient are these relations that the mind must recognise them directly it begins to think at all. Thus, whilst all other conceivable philosophies, one may suppose, have been held by men, there is at least no record of any philosophy that might go by the name of *Chaotism*. Whatever else is uncertain, the fact of order around us cannot be gainsaid.

The Idea of Order. Now surely we have already made a discovery of capital importance. Here, at any rate, is something which is so palpable that, however various men's minds or temperaments, their age or place or training, they must light upon it the very moment that they begin to think at all. There have been many philosophers who declared that there is no external world, many to say that if there is an external world we can know nothing of it, some to say that mind is only an accident, looking on at the matter which produces it—but never yet was there any philosophy that did not admit, to some extent at any rate, this idea of order. The order is outside us, say some thinkers; there is nothing whatever outside us and the order is within us, say others; the order only applies to some things, say the savage and the superstitious; order is universal, says the thinker—but none of them will deny the existence of order at all. Men have subscribed to every philosophy but Chaotism.

Now, once the mind has begun to recognise traces of order here or there, it has a way of going a little further afield, in order to see how far this principle may be traced. The whole history of science is a history of the ever widening demonstration of the existence of order, and it is the profound belief of all men of science to-day that order is universal. As a matter of fact, however, philosophers have not waited for, let us say, the perfecting of meteorology in order to assent to the proposition that order is universal. Those who have contributed anything at all to the history of thought have always believed that the order which we can recognise is indicative of order everywhere. Some have said that the order is without the mind, some that it is within the mind, but at any rate, it must be a general truth.

The Simplification of Things. Now, philosophy is a most difficult and arduous study, yet we may at least credit it with having simplified our ideas of the world. Let us take, for instance, what we commonly call matter. As we know, science has lately simplified our varying notions of varying kinds of matter, and has presented matter to us as one thing—whatever its real nature be—which presents itself to us under various forms. Later still, science has told us that this one thing may be expressed in terms of yet another thing, still more general, which we call energy. But philosophy has not had to wait for these conclusions of science. Recognising signs of order, and believing them to be indicative of universal order, philosophy has long anticipated science by regarding the external world as essentially a unit. Now, this is a great and most desirable simplification. It would be long ere we reached our goal, which is the heart of things, if we had first to make a specific examination of every object without us, every object that we can lay our hands upon, and every object that no hands can be laid upon. But philosophy has long ago agreed upon this, at least—that the exterior world, despite its apparent multiplicity, may be looked upon as a unit. The world we live in—whatever that phrase really means—is not a chaos but a cosmos. Science is every day more clearly proving that this is true, demonstrating, or beginning to demonstrate, its truth, where hitherto it had to be taken on trust. Hence, what was a most warrantable inference even for the first philosophers is a still more warrantable inference for us. We proceed, then, in all further discussion, to speak of what is without us—the "universe," the "cosmos," the "external world"—as *one thing;* we may speak of it as "it" and not as "them." Now, this is really a magnificent simplification of things; and, from the point of view of philosophy, the great service of science is that the more she advances the more does she afford warrant for this great simplification.

The External World. But though this constitutes an incalculable advance upon any supposition that we live in a higgledy-piggledy, it leaves us with abundance still to think about. It still affords room for differences of opinion which are profound and irreconcilable. Let us see, if possible, what forms these differences may take. The first opinion as to the external world is that which the phrase itself expresses. It is the opinion of common-sense and of crude realism. It is also the opinion of philosophers more advanced than these, but it is denied totally by a school of thinkers who, in their various forms, may be called idealists, and who regard what we call the external world as having no existence apart from mind.

But let us agree, for the present, at any rate, that there is this external world, whether it be the whole fact or only an aspect of the fact. The doctrine which denies its existence may here be left out of account. There still remains a great issue which goes right down to the depths of our subject. This is the issue between crude realism, which boldly asserts that things are what they seem, and the doctrine or doctrines which assert that the external world, as we know it, is not wholly known to us. And here there may occur to the reader the question which really does begin at the beginning: What do we mean by knowing?

The Criticism of Knowledge. For, after all, before we assert anything we should begin by ascertaining how we come to know it, in what sense we know it, what are the conditions and the limits, if any, of our knowledge. Certainly, knowing cannot be an absolute and perfect process as practised by us, since the results differ in every case, and furthermore,

we are each of us well aware of facts within ourselves that affect the measure and the quality of our knowledge. Plainly, therefore, all kinds of philosophising are premature until we have ascertained something about the instrument which we mean to employ. In what sense do we know anything, and to what extent?

The Great Work of Kant. Now, this was the great work of Immanuel Kant (1724–1804), and it is one of the most amazing facts in the history of thought that the doing of his work should have been left for so long. It is because the great work of Kant constitutes a criticism of men's thoughts and of the conditions of their thinking that it is generally described as the "critical philosophy." A somewhat uncouth word has also been employed—and is, indeed, now found indispensable—in order to indicate the study with which Kant chiefly concerned himself. This word is *epistemology*, from the Greek word *episteme* (knowledge). Just as biology, then, is the science of life, so epistemology is the science of knowledge, the science or the department of philosophy which concerns itself with the knowing process, the conditions, the limits, and the validity of all that we know or think that we know.

Now, there is one school of philosophers who have no use, so to speak, for any theory of knowledge. Epistemology offers them no difficulties and no problems. These are those who regard the external world as the creation of our minds. But for the rest of mankind this question of the validity of our knowledge is supremely important in its philosophic implications. Certainly we know something of, or concerning, the external world. Daily life demonstrates that. Whatever a man may call himself or wish to be called, he cannot be an absolute sceptic. Absolute scepticism is not to be found even within the walls of a lunatic asylum. A man may have many delusions, and they may all be ridiculous, but he will still retain a practical belief in gravitation.

The Value of Empirical Truth. There is, then, at any rate, some kind of validity in our knowledge. We act on the assumption that an unsupported object will fall, and we are found to be right. So far, very well. There is at least open to man some proximate, practical, working kind of truth. There may be more, but, at any rate, there is empirical truth, the word empirical meaning experimental or dependent upon experience. You know that under the present condition of things the sun will rise to-morrow. That is an empirical truth, demonstrated to be true by experience. Now, before we go any further, let us at least attempt to do justice to empirical truth, for it is too much scorned, perhaps, by professional philosophers.

The physical life is not the whole of life nor the most of it, nor the best of it; but for the most and best of life the physical life is at least necessary. Contempt of the body can evidently be pushed too far. Now, so far as this physical or bodily life is concerned, in point of fact, we *live* by empirical truth. As we look at it, it may be a most grotesque parody of the real truth. Critically considered, it may be worth very little or nothing for the purposes of philosophy; very often it may have led men ludicrously astray in their search for reality—but whatever defects it may have, whatever charges may be levelled against it, yet, at any rate, it is in virtue of our practical recognition of empirical truth that we men and women live. Even the philosopher who decries it is daily dependent upon his daily recognition of it; otherwise, any one of a hundred occasions in the course of a single day would put an end to his life. Empirical truth may not be—indeed, it certainly is not—the whole truth, but by it we live our physical life. Many men have lived and died and worked and suffered and achieved and sung with the aid of empirical truth alone.

We Have Enough Truth to Live by. The great fact of human life, indeed, is that men can and do live by empirical truth, proximate truth, relative truth—call it what you will. It is much more than doubtful whether Shakespeare had what the Germans call a *Weltanschauung*, or a consistent view of the world. It would be quite impossible to ascribe any philosophy to the greatest men and women in history. Even the kings of thought, after devoting all their lives to this study, have commonly confessed themselves baffled. Absolute truth may or may not be beyond the ken of man; it may or may not have been attained by any in the past; we may protest, if we please, against the nature of things for hiding itself from us—but most certainly it might retort that *we have enough to live by*. If human history demonstrates anything at all, it certainly is that even such light as is afforded to the simple-hearted is abundant for the living of worthy and even of glorious lives.

This is not, of course, to deny the truth of the great saying that "man cannot live by bread alone," but it is to deny totally that what is technically called philosophy is in any sense whatever a human necessity. The search for the deepest deep may be, and is, both valuable and fascinating, and well worthy of the fine striving that distinguishes the human mind, but it is not required to reveal the *vital* realities, as, for instance, that vital reality which St. Paul called the greatest thing in the world.

Truth and the Search for Truth. These are the realities by which we live, and they can be no more real to the profoundest philosopher than to the child on its mother's knee—though truly they may be less so. Certainly the man who neglected love and duty in order to search for remote truth would be convicted as no lover of wisdom and as blind to her, even when face to face. It is such considerations, also, that enable us to understand the full meaning of the famous assertion made by another great German philosopher, Lessing. He said that if God offered him truth in one hand and the search for truth in the other hand, it was the search that he would choose. At first sight this seems meaningless and monstrous, for pray what should give the search for truth its meaning or purpose but the possibility of finding her? Yet Lessing was profoundly right. He knew that the truths by which we live have already been given to us; he knew that one of these vital truths is the necessity to strive. That is why he desired to be given the

search for truth. He knew also that that absolute truth which philosophers seek, whatever her attractions, is assuredly not necessary to salvation. Human history denies on every page the doctrine that no one but a metaphysician is entitled to a religion; and all the philosophers of the past are but humble scholars at the feet of the child who risks its life in order to save another from the flames.

The Truth that is Essential. In a word, empirical truth—as, for instance, gravitation—suffices for the physical life, and the super-physical life is nourished by truths which may be hidden from the wise by their own vain imaginings, and yet revealed to babes and sucklings. Compared with either of these, philosophical truth is a thing of little moment. If, some day, there were revealed to us the nature of ultimate reality, the knowledge would not affect in one jot or tittle the ordering of our daily lives. The philosopher of that date would have the same difficulty as all philosophers of the past in bearing toothache patiently—as Shakespeare hinted. Nor, on the other hand, would this revelation be of the smallest moment for the moral ordering of life. Such words as justice, love, and duty would find nothing added by it to their significance.

So much, then, for the value of orders of truth other than philosophic truth. We must remember that the realities which vitally concern us are the realities of life and experience, and not the realities with which ontology seeks to deal; otherwise, where, after so many failures, should we be, and whither would there be any prospect of our going?

Having said so much, let us return to Kant's criticism of knowledge, and let us observe the conclusions to which he was led. They were briefly these: Our knowledge of the external world is limited and conditioned by the limits and conditions of our own minds; it is knowledge, not of reality but of appearances. The reality which lies behind those appearances must be in its essence not dissimilar to the perceiving mind itself.

What is a Phenomenon? The opposed words which Kant employed were *phenomenon* and *noumenon*. This word phenomenon, which is so familiar to us, is one of the most valuable and important words in philosophy, since it expresses for all those who know its meaning one of the most important ideas in philosophy. In vulgar use the word means anything that is out of the way or wonderful, and we apply the adjective phenomenal to anything which we wish to signalise as extraordinary. But these employments of the word are most unwise and unfortunate. The adjective phenomenal should be absolutely confined to its proper philosophic use of describing anything that has the character of a phenomenon. We shall see in a moment how convenient the word may be. A phenomenon, then, is literally an appearance or something that appears, and whenever we use the word we are to associate with it in our minds the idea of a something which, though hidden from us, and not apparent, is yet the reality, the self, or the thing-in-itself, lying behind the appearance or phenomenon, which is all that we can directly know. There is, then, on this terminology the real or the noumenal, and the apparent or the phenomenal. Our knowledge is only of what appears to us, and is therefore only phenomenal knowledge. (The reader will contrast this proper use of the word with the ordinary misuse of it.) Nothing is further from being suggested than that there is any opposition or contradiction between the real and the apparent—between the thing-in-itself and the thing as it appears to us. We are freely entitled to argue, in so far as we may, from phenomenon to reality. Merely it is asserted that our knowledge of reality must always be inferential, and can never be immediate or direct.

The Limitations of Knowledge. Now if the Kantian criticism of knowledge be valid —and we are about to see reasons for thinking it so—if it be true that our knowledge of the external world is only relative, the most serious conclusions must be faced. Here, again, is a case where the idealist escapes all our difficulties. To him the external world is just "such stuff as dreams are made off," and there is nothing behind phenomena, which are of the mind's own making. But if we class ourselves as realists, believing that something corresponding to what we call matter really exists, then observe what the Kantian criticism involves. We can know matter only by its appearances or attributes. That which stands under matter—the *substance* of matter (a great philosophic word being used in its great sense), we can never know; for we are aware only of the changes which its attributes produce in us. What we understand by science, then, is all phenomenal knowledge, and no more. It is a science of appearances, of the "co-existences and sequences between phenomena"; it is not knowledge of being or reality. This is by no means to say that phenomena are inconsistent with that which underlies them, or that if immediate knowledge of reality were vouchsafed to us it would be found to give the lie to our phenomenal knowledge.

The Limitations of Science. Ever since the publication of the critical philosophy, all but very shallow and soon-forgotten thinkers have found themselves compelled to admit that in positive science, as it is called, there can be found no final answer to the world riddle. This is by no means to decry science or to question the immense practical value of science—its services as a source of intellectual interest, and its facts as directly related to human life; it is merely to recognise the basis on which science rests and to which she is confined. Positive science cannot give a positive answer to any ultimate questions, but only to phenomenal questions or questions regarding phenomena. It was John Locke, one of the greatest of Kant's predecessors, who, in his "Essay Concerning the Human Understanding," defined the impassable barrier to our scientific knowledge. He showed that we have no innate ideas, and that we are dependent for all our knowledge and all our ideas upon *sensation*, in the first place, and, in the second place, *reflection* on previously gained sensations. His famous conclusion was:

"Nothing is in the mind that was not first in the senses." Now, this assertion in itself is not equivalent to the assertion that all our knowledge is only phenomenal. It might be that, as some of the Greeks supposed, sensations were due to faint copies of objects—ghosts or emanations—which were given off by them and entered our eyes But, as we all know, that very naïve idea has long ago been superseded, and the nature of sensation has been, in some measure, elucidated.

We Know Only Ourselves. The question, observe, is as to the nature of sensation, not as to its range. Our knowedge, of course, is imperfect so far as the range of sensation is concerned; our eyes appreciate only a narrow portion of the compass of a certain type of ethereal waves, our ears only a few octaves of those waves which, if audible, we term sound, and so on. But the really vital matter is not the range or extent of sensation, but the kind and degree of validity that must be attached to such sensations as we *do* obtain. The beginning of all that we know and all that we can conceive consists of changes in our own consciousness. We may make many inferences from these changes, and undoubtedly these inferences may be commonly justified by results. Nevertheless, at bottom, we know nothing more or less than changes in ourselves. When you look at this page you are aware of a change in yourself, a change in your consciousness, and nothing more. At first sight this may seem a somewhat startling way of stating the facts, and yet it will bear continuous thought, and only seem more and more valid. Here, in the admirably clear words of Lewes, is the reply of Kant and Locke to the dogmatist, after they have investigated the elements of thought:

"But this Understanding can never know Things *per se*. It is occupied solely with its own Ideas. It perceives only the Appearances of Things. How would it be possible to know Noumena? By stripping them of the *forms* which our Sensibility and Understanding have impressed upon them—*i.e.*, by making them cease to be Appearances. But to strip them of these forms we must annihilate Consciousness; we must substitute for our present Sensibility and Understanding a faculty or faculties capable of perceiving Things *per se*. This, it is obvious, we cannot do. Our only means of communication with Objects are precisely this Sensibility and this Understanding which give to Objects the forms under which we know them."

The Philosophy of Idealism. The philosophy called idealism may seem to each of us to be the very last thing that he could conceivably believe, yet it is interesting to observe how, again and again, the idealist thrusts his voice into our argument. At the stage which we have now reached, for instance, we have the voice of Berkeley, who overhears us saying that "all we are aware of are changes in our own consciousness." "Can you not see, then," he would say, "that what you are aware of and what you have admitted that you are alone aware of, is all that *is*? Material things have no objective existence—no existence outside yourselves: the external world which you persist in postulating as the noumenon or substance, the attributes of which cause changes in your consciousness, is a figment of your imagination. You put together in your mind certain attributes, such as form and colour and extension, shall we say, and then you invent something in which they subsist and which you call matter. But this is a creation of your mental act, and nothing more." "Verily," as David Hume remarked, "these are arguments which admit of no answer and produce no conviction." But at least let us try to understand them, and to respect them. They cannot be answered, as Dr. Johnson foolishly thought, by kicking a stone. Their conclusion is absolutely incredible, but they have never yet been answered at all.

Scepticism. So much for one solution of our difficulties when we come to criticise the conditions of knowledge. Apart from it, however, we seem to find ourselves landed in scepticism. Here, again, is a philosophic term which, like all the rest, has been used in many senses, and, as in the other cases, we must try to get from the word its full value. The doctrine of Kant, that our knowledge can only be phenomenal, is, of course, a form of scepticism. That is evidently a proper use of the word. There is happily passing from currency its employment to indicate someone who, for instance, doubted the truth of the story of the manufacture of Eve. Whatever we do, let us at least see in this word a purely philosophic term without any moral or theological implications of any kind.

The Kantian doctrine, then, we have said, is a form of scepticism, but we must clearly distinguish it from, for instance, the classical scepticism, or even from that of Hume. The sceptics of the antique world did not distinguish between the possibility of a science of phenomena and the possibility of a science of noumena or a science of being. Reflecting upon the limitations and conditions of our knowledge, and especially on the impossibility of discovering any absolute test of truth, they felt themselves compelled to deny the validity of all our knowledge whatsoever.

The Absurdities of Absolute Scepticism. But some indication of the absurdity to which such an attitude leads us may be found in such a remark of the sceptics as this: "We assert nothing—no, not even that we assert nothing." Such must be the absurdities in which absolute scepticism lands itself, and there is a world of difference between it and the position of Kant who said that "the understanding was not treacherous, but limited; it was to be trusted as far as it went, but it *could* not go far enough: it was so circumscribed that philosophy was impossible."

It is this relative scepticism, or this renunciation of scientific dogmatism, this formal assertion that science deals only with proximates, appearances, or phenomena, that characterises the greatest thinkers of to-day. It is, of course, a form of agnosticism, or, rather, agnosticism is a form of it Here, again, is a word to which

moral implications have been attached, but these we must here ignore. Now let as recognise at once that this renunciation of the right to dogmatise works out in more ways than one.

Agnosticism. For the moment let us assume that the preceding arguments are all valid, and let us see what follows on this assumption. First of all, certainly, there follows the explicit limitation of the range and rights of science. That limitation is extremely unwelcome to certain students of science, and is very commonly ignored by those who confine their study to the material sciences alone. On the other hand, this agnostic assertion of science regarding her own powers is extremely welcome to those who were distressed or disgusted at the claims which certain people used to make for science not so very many years ago. Everything pure and lovely and of good report, every belief that contained a vestige of beauty or of hope, the basis for everything and anything that made life worth living at all—these, we were told, must be abandoned. They were condemned by science, the all-knowing, and must away. This dogmatic position was held for some decades of the nineteenth century, though not by its most illustrious men of science. The complete renunciation of any right to dogmatise on ultimates has naturally enough brought great relief to those in whose eyes it seemed as if the dry light of science, claiming to illuminate human life, would succeed only in charring and blackening it.

But this is by no means all. It might well have been foretold that when, of two rival schools of dogma, one was found to declare that, after all, its knowledge was only relative, and its best dogmas were symbols, the opposing school should count the recantation as almost equivalent to an admission of *its* set of dogmas.

Dogmatism. It would be idle on a serious page to ignore the all-important historic fact of the controversy between scientific and theological dogma—a controversy which became so acute in the second half of the nineteenth century. But if we are to endeavour to be impartial we must be consistent with our criticism of knowledge. The honest man of science, for instance, will candidly admit that, owing to the fundamental structure and circumstances of the human mind, his knowledge is not ultimate, but relative, his dogmas are not literally true, but merely tentative symbols—all his knowledge, in short, only of the relative, only of phenomena, only of the surface. "But," he will go on to say to his adversary, "you, my friend, are in the same boat; you cannot have it both ways. You make many assertions of a striking character, not merely as regards the spiritual world of love and duty which you and I alike can know directly, but also regarding the world of sense and phenomena. The conditions of knowledge for me, so far as the world of phenomena is concerned, are also the conditions of knowledge for you."

In the light of such imbecile phrases as the "bankruptcy of science," it is well, perhaps, for us to state this aspect of the question. Having done so, let us go on to observe the consequences which have followed the application of the critical method to that which is by far the oldest, the most popular, and the most plausible of all philosophic systems—the system called materialism.

As has happened so often before in our reading, here we come upon a word to which improper meanings and innuendoes have been attached, more especially by those whose own philosophy, if it were to be examined, would be found ludicrously materialistic. By some curious set of sequences, the word materialism, which is properly a technical term of philosophy, has come to signify, in popular usage, nothing more nor less than Mammon worship. How this should have come about really does not matter at all, except that in part it has undoubtedly been due to the *odium theologicum*. At this late day, perhaps the best that we can do is to employ qualifying adjectives which will enable us to distinguish between two totally unconnected things—practical materialism and the philosophic doctrine called materialism.

Materialism. The confusion of terms is perhaps of lessening consequence since materialism as the name of a philosophic doctrine is no longer of any current value. The doctrine which was formerly called materialism requires to be renamed energism in its new form, as we shall see. Meanwhile, let us ask what the doctrine is. The philosophic doctrine known as materialism asserts that all reality, everything that exists, may be finally and completely expressed in terms of matter or "matter and force" or "matter and energy" or "matter and motion." As a working hypothesis this doctrine has never been so widespread and so generally accepted as it is to-day. It is interesting to note, however, that it is quite definitely, in these days at any rate, the philosophy of the half-educated. It would be very difficult to name any great living thinker who is a materialist, and it would be impossible to name any professed student of psychology who subscribed to this doctrine. Nevertheless, its importance as a system of thought cannot be over-estimated, and we must study it most carefully. We shall have to note, also, that materialism is now taking a somewhat more refined and subtle form in consequence of recent advances in the physical sciences, and that in this form it certainly gains both in plausibility and in importance, for it will now be found to make an appeal to many people whom the cruder materialism would have repelled. On the other hand, it loses weight with people of less mental calibre. Let us look at the history of this subject.

The Father of Materialism. Materialism may claim as its first parent one of the most illustrious men of the antique world, Democritus of Abdera (about 460–360 B.C.).

Beyond a doubt his was one of the greatest minds in history, not only in its actual constructiveness but also in its seminal or seed-bearing quality. His ideas, taken up by other men, have made a dozen great reputations that have lasted from antiquity until to-day. Yet of all his great sayings there is, perhaps, none greater than this, "We know nothing really, for the truth lies in the depths." This is a

profound epigram which his followers, as is the manner of followers, have too often forgotten. The vaguest part of his philosophy was certainly that which concerned itself with mind, and he does not seem to have been consistent in this respect. This is a characteristic of all materialists—if, indeed, we are absolutely warranted in calling Democritus such. At one time he certainly taught that "the body was made up of material atoms, the brain as well; the mind is a function of the brain, and for him the soul was the mind. It was made up of fine smooth, round atoms, similar to the atoms of fire; these are the most mobile of all; penetrating the body, they give rise to the phenomena of life."

The Essence of Materialism. Among his fellow countrymen Democritus found successors. Empedocles, for instance, working upon the idea of what his master was the first to call "atoms," wrote of the "loves and hates of the atoms," a doctrine which, as we must see, regards the atoms—that is to say, the physical—as the ultimate reality, and the psychical as a mere attribute or function or property of it. This is the essence of materialism: that mind is an attribute or property of not-mind, or, to phrase it in the older terms, that mind is a function of matter.

The most illustrious of the materialists after Democritus himself is the Roman poet Lucretius (about 95-52 B.C.). His great work was a long poem, "Concerning the Nature of Things," in which he expounds the principles of Democritus, transmitted to him through the writings of Epicurus. The poem is absolutely unique in literature: it is a poem not merely in form but also in substance, one of the most truly poetic, elevated, and beautiful poems that have ever been written. A line in it—directly due to Democritus—was destined, after some 1800 years, to generate the idea of the nebular origin of the solar system in the mind of a Teuton-Scot named Immanuel Kant—himself one of the greatest but one of the least poetic of men, destined also in later years by his criticism of knowledge to destroy the whole edifice of materialism at its very foundations.

Truth in the Dark Ages. Not long after the time of Lucretius, the life and thought of Europe were obscured in the thousand years of darkness. There were no great thinkers: truth, or even error seeking for the truth, had ceased to grow; nothing was achieved, nothing was learnt; materialism and all other philosophies might never have come into being. Then at last men awoke from their horrible sleep, and the breath of life was found to be not wholly extinct in the mind of man. It was not until the nineteenth century, however, with its wonderful unifications of scientific knowledge, that materialism really came to the fore again as a philosophic doctrine. It is fair to say, however, of the great materialists of the generation that is gone, as it is probably fair to say of Democritus himself, that they did not really regard materialism as the whole truth. They also realised that "truth lies in the depths" even though, short of that, everything, including even the facts of mind, seemed to be explicable in terms of matter and motion. The most notorious materialists of the nineteenth century were very far from being the greatest, and they certainly renounced any such doctrine as that truth lies in the depths. Some of their names may be noted.

Some Materialist Ideas. The first of them was Feuerbach, who will long be remembered as the author of the saying, "Man is what he eats." Closely following him was Carl Vogt, whose name in its turn will be remembered for his saying, "Thought stands in the same relation to the brain as the bile to the liver or the urine to the kidneys." Then Moleschott coined the famous phrase, "Without phosphorus no thought," leading him on to the conclusions that thought is a movement of the matter of the brain and that "without matter there is no force, without force no matter." Then there came the exceedingly celebrated work of Büchner called "Force and Matter" (*Kraft und Stoff*). It is the most famous of all materialistic treatises, and its date of publication, 1855, is worth noting. Many of the so-called materialistic assertions of that book are now commonly admitted. Our concern here, however, is not with them, historically important though they were, but with his assertion that mind, "like light or heat, electricity or magnetism or any other physical fact, is a movement of matter." His own words are that psychical activity is "nothing but a radiation through the cells of the grey substance of the brain of a motion set up by external stimuli." This involves the doctrine that your consciousness of yourself, your self-consciousness, is a material motion.

This is evidently the most ludicrous assertion that can be made; but that is materialism—which we are about to analyse more closely.

The Newer Materialism. There are really good reasons why the word "materialism" is ceasing to have any but historical interest. One such reason, certainly, is the confusion of the word with certain moral issues in a wholly irrelevant manner. Yet another, and a still more important, reason is that in the present state of science the word does not at all express any form which can be assumed by the doctrine for which the word stands. What materialism really means is that the external world is the only reality, and that the psychical is a more or less accidental property of it. But the word as it stands says more than this, for it suggests a purely scientific proposition—namely, that the external world can be resolved into matter. Büchner himself, at the last, besought his followers to abandon the word "materialism" and to substitute "*monism*" for it, his reason being the very proper one that "a philosophy not of matter as such, but of the unity of force and matter, is not materialism." Nowadays we substitute the word "energy" for "force," and then the criticism holds—indeed, it much more than holds, as we shall see. Büchner's advice has, indeed, been followed, and the word "monism" has come to succeed very largely the older term. The word is important, and we must examine its uses.

Continued

INFECTIOUS & NERVOUS DISEASE

Typhoid, Diphtheria and other Infectious Diseases. Organic and Functional Diseases of the Nervous System. Ill-Health of the Special Senses

By Dr. A. T. SCHOFIELD

INFECTIOUS ILL-HEALTH

THE subject of infectious ill-health has been treated from a hygienic point of view in some detail. What is said here will be supplementary to the consideration already given to the subject in the HEALTH articles.

Typhoid Fever. Cholera and smallpox have been fully treated. In typhoid fever, we have a disease that runs for three to four weeks or more. It is generally preceded by a fortnight of weakness and depression, and then the temperature rises to 103°, and the diarrhœa begins. There is often a slight rash on the stomach. The third week is the most critical. The ulcers in the intestines are then at their worst, and if they perforate through the walls, death ensues. There is often delirium and extreme weakness. There may be hemorrhage. About one in six dies of exhaustion. In this disease skilled nursing is essential, as well as medical care, and nothing but liquid food must be given until the temperature has been normal for one week. Great care is needed in convalescence, as the heart is always much weakened, and for a month or two after there should be no violent exercise or strain of any kind.

Diphtheria. Diphtheria has also been spoken of as regards its causes. It is an epidemic and poisonous sore throat that starts gradually. The local inflammation is severe, and the temperature rises to 102°. The membrane, that forms like wash-leather, may extend down the throat or up the nose, and produces great difficulty of breathing and swallowing. There is great weakness, and death often occurs from exhaustion as from suffocation. Recovery is very slow. The great principle is to support the strength in every possible way, so as to enable the body to fight a victorious battle. Of course, the patient is kept in bed, and the air must be kept warm and moist. A skilled doctor and good nurse are needed, and in bad cases the injection of antitoxin is the most efficacious remedy. In convalescence, very generous diet and bracing air is needed.

Measles. Measles is an infectious catarrhal fever, with a crimson spotty rash. In the German variety there is more sore throat and less rash. All the mucous membranes are inflamed, and the sneezing and coughing distribute the infection through the air. It is most contagious at the beginning of the disease, when the catarrh is acute: the eyelids are red and swollen. The eruption appears on the fourth day, and lasts four days, and is in the form of red dots arranged in crescents. It often affects the eyes and ears permanently, and hence care is required in all bad cases to avoid this. Medicine is not much needed; a bed in a warm room, well isolated, with mild milk diet, is required.

Typhus and Scarlet Fever. Typhus fever is so rare now in this country that it need not be described, nor must it be confounded with typhoid fever, which is still common. Scarlet fever or scarlatina is an infectious fever in which the skin becomes scarlet from a very minute eruption, which starts about the second day and subsides about the fifth. The throat is inflamed and very sore. Like measles, it is common in childhood, but is more dangerous and leaves worse results behind it. The fever rises higher, and there is special danger of inflammation of the heart and kidneys. After the rash has subsided the old skin begins to peel off, either in fine dust, like bran, or in larger pieces. This is a slow process, and sometimes takes six weeks, as the bits of skin spread the infection everywhere; the patient has to be most strictly isolated until it is quite completed, the toes being always the last to be affected.

In simple cases, a warm room, light food and free action of the skin by warm drinks is sufficient. When the peeling begins, the skin should be oiled to prevent the particles from flying about. As soon as the temperature is normal good nourishing food is required, and after all is over a month or so of convalescence is needed. A doctor should always be called in to watch the heart and kidneys.

Chicken-pox. Chicken-pox would be a trifling complaint were it not that the rash, which consists of large scattered vesicles, few in number, tend to form large and unsightly scars which, when they occur on the face, are most disfiguring. Every care should be taken to prevent the face being marked, but little other treatment is required.

Influenza. Influenza has been spoken of pretty fully in the section on HEALTH. It is enough here to impress the fact that the weakness caused by the disease is out of all proportion to the apparent severity of the attack. Every care should be taken to avoid chill, especially after the attack is over. This is the time when fatal pneumonia may readily be set up and death ensue. The nervous system often suffers severely after this disease.

Erysipelas. Erysipelas is a contagious disease that, as a rule, attacks some wound or sore in the skin. It produces great redness and swelling, and in the head it is very dangerous. The parts affected should be either treated with poultices or ice cloths, and the strength kept up and all chills avoided.

Relapsing and Remittent Fevers. Relapsing fever runs very high, up to 107°, with remission caused by profuse perspiration, which lowers the temperature. This generally occurs on the fifth or seventh day, and then for an equal length of time the patient appears quite well, when the fever returns as before, but for a shorter period. There is no special treatment.

Remittent fever is a malarial one due to the bite of a gnat, and is somewhat like relapsing fever, but the fever does not wholly abate, but only lessens, and that only for a few hours. Quinine is of great efficacy here.

Mumps. Mumps is a highly infectious disease that attacks the glands at the angles of the jaw, with acute pain and swelling. There is fever, and a difficulty in taking any solid food. It is common

in children, and lasts about a fortnight. Poultices, warmth, and light diet are needed.

Whooping-cough. Whooping-cough is an infectious disease of childhood consisting of violent paroxysms of coughing. It lasts about six weeks. The e is a spasm of the bronchial tube and a feeling of suffocation. Fresh air is good. In severe cases a doctor should be seen. It lasts from four to eight weeks, as a rule, and causes great weakness.

The other infectious diseases, such as plague, yellow fever, anthrax, glanders, tetanus, etc., are, fortunately, sufficiently rare in this country not to require special mention.

Finally, one may say that the infectious diseases are theoretically all preventable, and most of them are so, practically; and while with regard to treatment, if the case be mild, simple rest in bed till well is the main thing. In the severe cases, and those with complications, medical care is essential.

NERVE DISEASES

We now reach a class of disease that is of unusual interest, as with the increasing complexity and pressure of life it is getting more and more common: so common, indeed, that it is probable that there is no one who reads these pages whose family is wholly free from it.

The worst is that there are not only a large variety of nervous diseases, but, as the nervous energy is really the driving power of all the complex organic machinery of the various systems of the body, when it is deficient in force it is quite possible there may be no definite disease. And yet there is such a general lowering of the activity and force of all parts of the organism that it amounts to a condition far more distressing than many diseases. This nervous debility is very common in minor degrees amongst many who work hard, all who worry, and more who idle; and yet it is only when it is very severe that it is recognised as a disease and called neurasthenia.

We will briefly glance at the leading organic diseases, and then at those which are functional.

Neuritis. This is a rare disease when it consists of inflammation of the nerve trunks, but as an affection of the minute nerve endings (peripheral neuritis) it is fairly common. There is a great feeling of numbness, together with pain in the part affected, which may be a limb or some part of the body. When it affects the body it is often called *Herpes*. It throws out a cup of small pearly vesicles over the course of the inflamed nerve often like a girdle halfway round the body. These are intensely painful, and last a week or more. In neuritis we get little or no general fever, but the affected parts must be protected and the patient got into good general health. Neuritis often arises from some form of nerve poison, particularly arsenic. Hot fomentations and water dressings are often needed, and some faradic electricity is useful in resting the sensation of the affected part.

Apoplexy. Apoplexy is a sudden state of insensibility brought on by a clot of blood in the brain or the rupture of some blood-vessel. It is therefore common in elderly or plethoric people, where the blood pressure is too great, or the arteries too weak. High living, sedentary habits, short necks, and obesity also predispose to it. The patient becomes suddenly unconscious, and paralysis of one side (the opposite to the part of the brain affected) often follows; or death may ensue at once. The respiration is slow, the body clammy, and froth appears at the mouth. All clothing should be loosened, and cold water applied to the head; great care is needed in giving anything by the mouth, and enemata are often useful. It is, of course, necessary for a doctor to deal with the case.

Meningitis. Meningitis is an inflammation of the membrane covering the brain. It is most dangerous, and when tubercular, as in consumptive people, rapidly fatal. It is common in children, and may arise in its simple form from a blow or fall, or ear disease or sunstroke. The symptoms are fever, great pain, twitchings, delirium, squint, and, when it extends to the upper part of the spinal cord, retraction of the head. Medical advice should be sought at once. The brain itself may be inflamed.

Encephalitis. The symptoms are similar to meningitis, with vomiting and convulsions. The disease is fatal.

Chorea or St. Vitus Dance. This is a disease of childhood, with irregular movements and twitchings due to some brain disturbances. The child should be isolated, well fed, and kept quiet and restful until the disease is cured, which generally takes several weeks. A doctor is needed.

Insanity. Insanity may spring from a variety of causes, the chief of which is hereditary. If acute, it is called mania; if partial, monomania; if nerve weakness, dementia; if the intellect is absent, idiocy. The best treatment is removal from all exciting causes with plenty of distraction or occupation, healthy surroundings, good plain food, and plenty of sleep.

Diseases of the Spinal Cord. Diseases of the spinal cord are either paralysis or spasms of various parts of the body, according to the region of the cord affected, or the inflammation of the cord, with agonising pain over the spine. As a rule, spinal diseases are incurable, and though they do not threaten life like diseases of the brain, they often cause lifelong misery.

We now turn to the functional nerve diseases, which we will consider in more detail, inasmuch as they are more common and easier to understand and treat than the organic diseases of which we have been speaking.

Headache. Headaches fall naturally into two great classes, those inside and those outside the skull. We will first of all consider the causes and varieties of "external headaches"—headaches due to something wrong between the skull and the skin. In every case this "something wrong" is a nerve or nerves; all external headaches are, therefore, essentially neuralgias, or nerve-pains. Frequently they are across the forehead, less often they are at the back of the head; sometimes, again, they may include "tic" or faceache, and involve the nerves of the face. Sometimes, again, they seem to start from the ear as a centre, and play more round the side of the head.

These headaches are not generally caused directly through study, but are due either to general ill-health, or to some local chill or inflammation. A tight hat, pressing as it does severely on all those scalp-nerves, is often the cause; great bunches of hair coiled up behind is another. A cold east wind blowing on the forehead is another. They may spread from other nerves; toothache or earache, for instance, may cause this headache.

These are the headaches where local applications are very good, such as menthol, crystal and ointment, cold and heat, many liniments, and, if the ear be affected, a single drop of chloroform on cotton-wool.

One particular form of this headache seems to take exactly half of the head or face, beginning

with a disturbance of the eyesight, and going on to violent sickness, often accompanied with a terrible pressure.

In headaches of this intensity sleep is a panacea, and it can generally be obtained naturally or artificially, the former being of course the best. We will consider means of best producing this later on.

Neuralgic Headache. Let us always remember that in these neuralgic headaches, heat, properly applied, will always subdue surface pain. For instance, for a neuralgic headache that will not yield to other remedies, put the kettle on the fire, and a basin on the table, with two squares of flannel. Pour boiling water on them, and then nip one up by the corner, and drop it in a towel fixed by one corner round the leg of the table, or anything else, and then twist away at the other, wringing the flannel dry. Put this on the head, and immediately seize the second piece, wring it, and now taking off the first piece, and dropping it in the water (kept boiling) put it on the head. Now take the first piece out of the water again, wring it, and place it on instead of No. 2, and so on without ceasing, and in a few minutes the pain will be subdued.

Let us now think of the larger subject of true internal headaches, commonly arising from too little or too much blood circulating in the brain.

Internal Headaches. Some people have very little and very poor blood in the body—not enough to be everywhere at once; so if they study, it goes to the head and leaves the feet cold, while if they eat, it goes to the stomach and leaves the brain bare, and brings on a headache. It is indeed difficult for anyone effectually to use body and brain at the same time.

Headache from deficiency of blood in the brain may be recognised by its being at the top of the head, by pallor, by dizziness, and frequently by noises in the ears. These are the headaches benefited by slight stimulants—strong tea or coffee, hot soup—anything, in short, which increases the circulation; also by lying down with the head low. Such people should also sleep with the head low.

The opposite state is when the head is too full of blood, the face flushed, the temples throbbing, the pain excruciating, and the patient unable to bear a strong light or much noise. This is a "splitting headache," and seems to be all over the head. It is brought on in those who have plenty of blood by worry, by too much study, by irregular or too rich living, by gout, and is often accompanied by palpitation of the heart and dyspepsia. Mustard foot-baths are very good in these cases.

Bilious Headaches. We all recognise a bilious headache with its weight across the forehead, its spots before the eyes, its feeling of nausea, and the intense and instant relief when at length sickness comes on. Of course, such a headache in a weak or sickly person is much intensified.

A fourth variety arises from pressure or disturbance of the nerve substance of the brain itself. It is a dull, heavy pain, sometimes splitting in character, and sometimes with dim sight. It generally reaches from the forehead right on to the top of the head. Here again, strong light and noise are much disliked.

Amongst other causes, it is brought on by a long railway journey, the vibration of which has produced innumerable slight concussions of the brain, and altogether shaken it pretty considerably. A good meal will sometimes relieve it, sleep at other times, or the mustard footbath again; but in many cases nothing will do but medical advice.

Yet another headache seems to spring from sheer exhaustion. It is a headache all over the head, and is relieved by a good meal and cessation of all brainwork. Strong coffee with a biscuit will relieve it.

In the aged headaches are common from defective circulation in the brain arising from changes in the blood-vessels consequent on age. They are hard to cure, and hard to bear. Sleep also is not easy to obtain in advanced age, and probably the best remedies are gentle stimulants; if too strong they become dangerous.

How to Prevent Sleeplessness. Sleep is such a cure for most head troubles that one or two hints as to how to best obtain it may fittingly close our remarks on this painful subject.

A cold bed is often a great hindrance to sleep. Cotton sheets instead of linen, and in cold weather a warming pan, will frequently make all the difference between a good and a bad night.

Cold feet, again, are another fertile cause. These can be best cured by having, just before going to bed, two basins, one of very hot, and the other of cold water, and putting a foot in each, then crossing them and putting the warm foot into the cold water and vice versâ. The constant change violently stimulates the circulation. If, then, a pair of fleecy sleeping socks be drawn on, no sleeping draught will probably be needed.

If you wake in the night, and lie awake, getting up in the cold and taking a turn, and then returning to the warm bed will often produce sleep.

If the body is too hot, an arm or a leg left outside the clothes will lower the temperature.

Fresh air is a truer and better soporific than poisoning with carbonic acid gas. Therefore sleep with the window open and the door shut.

If the head be hot or throbbing, lie with the head high, and, if necessary, wrap the legs round with wet clothes covered with waterproof. This is an excellent plan.

Hunger and Sleeplessness. Hunger is a common and unsuspected cause of sleeplessness and also of headache. People dine at six or seven, and have nothing more till nine next morning. Others dine at one or two, and have a cup of tea and a slice of bread-and-butter at seven, and nothing till next morning. These people go to bed hungry and lie awake. A sufficient supper at a reasonable hour—a chop, or a bowl of hot bread-and-milk, or a plate of oatmeal porridge—will make all the difference, and in drawing the blood to the stomach will enable the brain to rest.

Another cause of sleeplessness is brain excitement late at night. The brain gets so full of blood that it cannot rest. Here the remedy is obvious.

Functional nerve diseases generally are, as a rule, little understood, and meet with little sympathy.

Listen to the usual treatment of a nervous case. When one of these victims to hypochondria, who are commonly called *malades imaginaires*, has recourse to medicine for the relief of pain, or some other disturbance, he is usually told it is of no importance; that he is fanciful, and some anodyne is carelessly prescribed. The patient, who is really suffering the pain he has suggested to himself, feels convinced that his malady is not known, and that nothing can be done for him. The idea that his complaint is incurable becomes intense in proportion to his high opinion of the physician's skill; and thus the patient, who was suffering from the painful affection suggested by his mind, often goes away not only uncured, but incurable.

A disease due to the imagination is not necessarily an imaginary disease, but may produce various functional and even organic disturbances. A wise physician once said: "If a man is so ill as to say he is ill when he is not ill, he must be very ill indeed." The diseases grouped under the heads of neurasthenia, hysteria, and so on, are real in origin and effects, and formidable in their nature; and it is high time that the ridicule, the offspring of ignorance, with which they have been so long surrounded, be entirely done away with. A nervous invalid is a far greater sufferer than a man with a broken leg; but we are content to dismiss the former as "only hysterical," and more sympathy and less contempt is often felt for a drunkard than for a neurastheme.

Nervous people are the very salt of the earth, and the leading in every profession are drawn from their ranks. They are men with brains that thrill, that feel, that are quick in action, firm, clear, and of high organisation. It is the nervous men that rule the world, and it is the children of these people who, inheriting the nervous organisation of their parents without having their safety-valve of hard work, form the bulk of our nervous sufferers. At the same time, just as a man can get gout from too little food as well as too much, so we have a large class who are ill from too much work and worry, instead of too little. The nervous diseases among this class far outnumber all others.

A Disease that is on the Increase. Neurasthenia is the general result of overstrain of the nervous temperament, and is said to be on the increase, the growing tension of life being quite a sufficient cause. Constant brain irritants in the ideal centres, in the shape of small but perpetual worries, render the other nerve centres as morbidly sensitive as a constant succession of slight needle-pricks all over the body would the terminal sensory nerves. The manifestations of the early irritant stages of neurasthenia are numerous. Physically they may include constant movement of the body and face, sharp cough, hoarseness, quick breath, starting and palpitation, timidity, irritability, melancholy, and a dread of being alone or in a crowd. If neglected, it may end in hysteria or organic disease.

Referring to the three divisions of the brain, the cause may be said to be largely the result of want of control by the upper over the middle district, which may be due to inherent weakness or to exhaustion from overwork or worry. The constant movement characteristic of this condition is in itself a sign of weakness in the higher centres. A baby is always in motion. As we grow older we get quieter, and the man with the strong brain only moves for a definite purpose. Repose, not movement, is a sign of brain power.

The further stage of nervous debility is a still worse disorder. It is the manifestation of nerve exhaustion rather than irritation. It is the frequent result of excesses of all kinds. It is characterised by physical weakness, mental lassitude and apathy, occasionally varied by a false and capricious, but evanescent, energy. It is often combined in varying degrees, as would naturally be supposed, with nervousness. In both of these disorders the first step in treatment is to seek out, and, if possible, remove the cause. Skilled treatment of a special character is, as a rule, needed.

Hysteria. Hysteria is a nerve disease of a different nature altogether, though it may be the result of the preceding disease, or may arise from any sudden mental or physical shock; or it may spring from hereditary causes, as we have already seen. The disease is most common in the spring, when the nerve system is least balanced. It often consists in the distinct manifestation, or perfect simulation, of disease not merely in irregular bodily or mental action. In hysteria proper there is no intent whatever to deceive, and it must carefully be distinguished from malingering, which is a direct attempt at fraud, and for which no contempt and ridicule can be too severe.

Hysteria is, on the contrary, a real and most distressing disease. It is common in the under and overworked, in the badly trained and imperfectly educated; in boys from ten to fourteen, in girls from sixteen to twenty-five. Over-education and subsequent idleness combined are fertile causes. It is often found in people otherwise strong-minded and clever.

Hysteria is so common that in many classes of ailments it is the general cause, organic disease being the exception. Sir B. Brodie states that four-fifths of joint disease among the upper classes are hysterical, and one-fifth amongst the lower.

Hysterical Symptoms. Amongst other symptoms of hysteria may be included sharp cough, spasms, convulsions, and choking from a ball rising in the throat. The spasms may be of any muscle, as of the chest, producing difficulty of breathing; or of the arm, or leg, or finger, or toe, producing temporary or permanent contraction of the part. The convulsions or hysterical fits are violent, and are greatly aggravated by any notice or sympathy. The patient falls without hurting herself, and the fit rarely occurs when there are no bystanders. Nevertheless, the hysterical convulsion is not a sham. It is generally preceded by the feeling of a swelling in the throat.

Hysteria also simulates every known disease, including tumours, deafness, blindness, dumbness, paralysis, St. Vitus dance, and so on, and is capable of producing, curiously enough, the highest temperatures of fever.

The first thing in treatment, of course, is to ascertain that the disease is hysteria only. This is a most difficult thing to verify in such patients, and nothing is more common than to find a disorder of the mind treated as a disease of the body. If there is, however, clearly no organic disease at the bottom, then the case must be one arising from nerve disorder, the cause of the nerve disorder being either physical or mental, or often a combination of both, the brain being, of course, wholly dependent for healthy action on good blood.

The Course of the Disease. A vicious circle is often kept up in these cases which it is absolutely essential to break. They begin, it may be, with loss of appetite from some slight cause. This, in these cases, leads to disordered thoughts, and the idea of disease begins. This, again, makes the appetite still more capricious; the thoughts, therefore, get still worse, and so the body starves the brain, and the brain the body, and the emaciated patient having, probably enough, first of all worn out her friends, sinks at last into her grave from sheer exhaustion.

The first thing, obviously, is to remake, as far as possible, the vitiated body and brain with fresh flesh and blood and nerve; and then, when we have put the patient into the best possible bodily health, we shall have cured the physical cause of the nerve disorder, at any rate. Then, or even simultaneously, any mental and possibly moral, cause must be deliberately, scientifically, and systematically attacked by the careful substitution of good habits of thought and action for bad. This

is done mainly by suggestion, but without any of the doubtful and unpleasant accompaniments of hypnotism.

Cure by Suggestion. It is important to remember that when the brain is restored to health by good nerve tissue and healthy blood, it can be made by suggestion to exercise as healthy an influence over the body as previously it exercised a harmful one. If ideal centres can produce ideal diseases, surely the rational cure is by first bringing these ideal centres into a healthy condition, and then making them the means of curing the ideal disease. Mental disease requires and can ultimately be cured by, mental medicine. Tonics, in helping to build up the new flesh and blood, are, of course, valuable.

Electricity, properly applied, is also a therapeutic we can seldom wholly dispense with; and the reason of its value is obvious when we consider it is the most powerful agent that we possess for direct action on the nerves.

If the case be a severe one, it must be withdrawn from all its surroundings during the cure; and afterwards, if these were bad, it must never return to them again.

DISEASES OF SPECIAL SENSES

In considering, as we will now do briefly, diseases of the special senses, we will at first confine our attention to diseases of the eye.

Squinting. Squinting is often caused in children by short sight, and sometimes by over brain pressure. It can often be remedied if treated early enough. If allowed to persist, the sight soon deteriorates in the squinting eye. If an operation is required, it is a safe one, and, as a rule, successful

Styes. A stye is an inflammation of the root of the eyelashes. It can sometimes be cut short by pulling out the inflamed eyelash and touching the part with caustic or carbolic. Hot fomentations are also good. An ingrowing eyelash should be pulled out.

Cold in the Eye. If the cold, or *conjunctivitis* is severe a doctor should be consulted. In any case, the patient should remain indoors, and bathe the eye with warm water in which alum has been dissolved in the proportion of half a teaspoonful to a large jugful. It is very dangerous in these cases to use any old eye lotion, as incurable blindness may result.

The ophthalmia in inflamed eyes of children is extremely contagious, and should be cured at once.

For a " black " eye, hot fomentations, or bathing with spirit and water, tincture of arnica or hazeline, is best.

If anything gets in the eye, rub the sound eye well, and the dust will often fall out of the other. Never rub the injured eye. Drawing the upper eyelashes over the lower often wipes the dust out.

Myopia. Myopia is short sight, resulting from the eyeball being too long, so that the rays of light, instead of coming to a focus or point at the retina, or back of the eye, come to a focus in front of it, and by the time they reach the retina have separated again and produced a blurred image.

This is corrected by concave glasses, which, by separating the rays of light, prevent their converging so soon and bring them to a point on the retina, giving a sharp, clear image.

Hypermetropia. This is short sight from exactly the opposite condition. It is very common among children, and leads to bad squinting. In this case the eyeball is too short, and the rays of light have not time to get to a focus on the retina, but would come to a focus behind it. The image in this case is also blurred.

Owing to the power we have of making the lens in the eye rounder, we can make the focus the right length by a strong muscular effort. This, however, not only tires us, but as the same nerve that supplies the muscle of the lens also supplies the muscle that moves the eyeball inwards, this gets contracted too, and thus, in the effort to obtain clear sight, children produce an internal squint.

The proper way to treat this condition is evidently to wear *convex* glasses, which, by bringing the rays of light together more quickly, enable them to get to a focus in the short eyeball without any strain.

Cataract. Cataract is an opacity of the lens of the eye. It is one of the most curable of serious eye diseases, and in China and India the operation is often performed successfully many times each week by young English lady students and others. It consists in making a small slit in the side of the cornea, through which the opaque lens is slipped out. Of course, to see properly afterwards, glasses of proper convexity must be worn to take the place of the missing lens.

Presbyopia. This is a hardening of the lens from old age, and generally begins to come on at 45 or 50. For reading, and any use of the eyes that make it necessary for us to alter the shape of the lens, which has become difficult, great relief is found in wearing slightly convex glasses.

We must now turn to diseases of the ear and voice.

Deafness. Deafness is generally the result of repeated and neglected colds. Beware of putting drops in the ear without medical advice, or of using sharp instruments. Medical advice is always required in these cases, and also in all discharges from the ear, which, however, may be gently washed away with a syringe and a little Condy's Fluid.

In cases of abscesses in or behind the ear early advice should be sought, as in neglected cases the inflammation may extend to the membranes of the brain and produce fatal meningitis.

Vertigo. Vertigo may almost be called a disease of the ear, as it is dependent on a disturbance in the semicircular canals.

Noises in the ear are most distressing. They may be caused by the pressure of wax on the drum of the ear, but as a rule are the result of some chronic trouble the in internal ear, and are incurable. The best plan is so to improve the general health that the noises can be endured.

The Voice. The voice, too, is often in trouble. In sore throats and laryngitis it is reduced to a whisper, and the loss of voice often persists long after the cause has disappeared, particularly in nervous people.

Sometimes the loss of voice is not from any such cause, but is due to paralysis of one of the vocal cords, or some pressure on them from a new growth. Persistent loss of voice not due to colds or sore throats should at once be seen to by a medical man.

Continued

MILITARY ENGINEERING

The Work of the Military Engineer in Peace and War. Bridges, Roads, Trenches, and other Work

MILITARY engineering differs from civil in that *time* is the governing factor. The military engineer should be trained to have a thorough knowledge of civil practice, of labour and trade methods, of all mechanical engineering, of machinery, locomotives, rolling-stock and motor transport, of electrical engineering, of power, lighting, telegraphs and telephones, and of all railway work, including both traffic and permanent-way departments. It is his business to adapt all this knowledge to the furtherance of the wishes of the commander-in-chief in war. To this end he must also be thoroughly trained in all branches of the art of war, including strategy, tactics, military history, in the organisation and composition of all branches of the service, and must have a complete knowledge of all armaments, with the effective ranges of all arms and the penetration and explosive radius of their shell. These duties in the British Army are carried out by the corps of Royal Engineers.

Engineering on Active Service. On active service, military engineering roughly divides itself into the following heads:

Passing rivers; bridges of the floating, trestle, frame, tension, suspension, or cantilever type; aerial tramways, railway construction and administration along the lines of communication; the repair of steel bridges, roadmaking, water supply, field fortification, including trenches, redoubts, blockhouses, defensible posts, siege works, sapping and mining, telegraphs, field telephones, and searchlights; balloons, housing of hospitals on the lines of communication, and housing of troops.

In peace time only the following can be called military engineering—namely, the construction of magazines, coast defence, and permanent fortification generally.

Passing rivers may be accomplished by fords, or on rafts and boats, or by bridges: floating bridges are the quickest to make when suitable materials are at hand.

Fords (or drifts) should be marked by stakes driven in the river-bed. A ford, to be passable for infantry, should not exceed 3 ft deep; for cavalry, 4 ft.; and for carts containing ammunition, 2 ft. 4 in. Large stones should be removed from the river bottom, if possible. If the river is swift, a life-line stretched tightly across on strong stakes is of great value. Approaches must be prepared on both banks; the exit should have a good straight pull for teams of animals, and should be made up as described later under Roads.

Floating Bridges. The site will most often be roughly fixed by the military requirements of the case, but for convenience of construction the banks should be low, with good, firm ground to furnish approaches; and the bed of the river at the banks, in tidal waters, should have a gentle slope on which the barrels or piers used in the bridge can rest as the tide falls, thus obviating complicated rise and fall of tide arrangements.

After selecting a site, measure the width of the river. If direct measurement is difficult, the far side of the river being inaccessible, the following device will serve. Select some convenient point, A, on the opposite bank [9], and mark the point B on the near bank, where the end of the bridge is going to rest; then peg out any point, C, in line with A and B. Lay off a line, CD, at any convenient angle. Take any point, E, in this line; lay off the angle DEF equal to the angle DCA; mark the point F in a straight line between D and A; measure DE, DC, and EF; then AC : CD :: FE : ED. Hence, AC and AB are known.

Floating bridges consist of a continuous roadway on piers of pontoons, boats or casks. The minimum width of roadway required in the clear is as follows: 1½ ft. to 3 ft. for infantry in single file; 6 ft. for infantry in file, cavalry in single file, or military carriages man-handled over; 8 ft. for infantry in fours, cavalry in sections, or military carriages fully horsed; 9 ft. is the normal width allowed, and 10 ft. allows a single man to pass over in the opposite direction to the stream of traffic. If hand-rails are given, allowance must be made for projection of axles.

The following weights per lineal foot of roadway must be allowed for in all bridge calculations (they include an allowance for shock or "live-load"): Infantry in single file, 140 lb.; in file, 280 lb.; in fours, 560 lb. Cavalry in single file, 196 lb.; in half-sections, 390 lb.

Infantry *actually* weigh 160 lb. "dead," when unarmed, and 200 lb. armed per man; 1 ton per axle will cover the weight of field and horse artillery, and axles average 8 ft. apart. Weights of other carriages may be got from service manuals.

Pontoon Bridges. The simplest floating bridges are made with pontoons. They are of three kinds—*light*, for infantry in single file; *medium*, for infantry in fours, and guns; and *heavy*, for cavalry in half-sections or a 6-ton steam sapper, elephants, etc.

Pontoon waggons each carry one bi-partoid pontoon, and one 15-ft. bay of superstructure 10 ft. wide. This superstructure consists of five baulks, 15 chesses (or flooring planks), two ribands, and various small lashings. Each pontoon is fitted lengthwise with a saddle, on which the baulks (3½ in. by 6 in.) rest, being secured by iron claw ends. The chesses (1½ in. by 12 in.) are laid across these baulks, and are secured by lashing ribands (3½ in. by 6 in. timber) over their ends. Figure 23 is illustrative.

For *medium* bridges, five baulks are normally used, spanning from one pontoon to the next, and each whole pontoon with its set of superstructure will provide 15 ft. of bridge.

For *light* bridges, the half-pontoons are used separately with three baulks from one to the next. The chesses are placed longwise on top. For *heavy* bridges three half-pontoons are joined together, and nine baulks are used to each bay. Two saddles must here be used to each pier of pontoons, and the roadway will be made no wider than for the medium bridge [see **1, 2,** and **4**].

A bridging company, Royal Engineers, can make 165 yd. of light, 85 yd. of medium, and 55 yd. of heavy bridge; a field company Royal Engineers can make 25 yd., 15 yd. or 10 yd. respectively.

The *buoyancy* of each half of a pontoon is 7,000 lb., immersed up to the gunwale, of which 1,000 lb., 2,500 lb., or 3,500 lb. (light, medium, or heavy) is taken up by the weight of the bridge itself.

Bridges with Boats or Barrels. *Boats* can be used instead of pontoons. The best way to test their buoyancy is to load them with men down to the safe limit; the weight of men, and hence the buoyancy, is then known.

A rule of thumb for infantry in fours is given. The number of unarmed men that the boat will safely hold (with 1 ft. of gunwale above water) divided by 4 equals the central interval between the boats. At the same time, the width of waterway between piers must never be less than the width of one pier.

In other respects, boats are treated just like pontoons, the only difficulty being the fixing of saddles to transmit the weight of the bridge to the boat. This should be done by upright struts to the keel, or cross-pieces across the gunwales. If two boats are to be joined together in one pier, place them stern to stern [5].

Barrels or *casks* can be used, lashed to long spars to form piers; good watertight barrels will rarely be found in sufficient quantities to be of any practical use, except for shore ends.

The buoyancy of a barrel $= 5\,C^2L - w$, where C is the mean circumference of the barrel in feet, L is the length in feet along a stave, exclusive of the end projections, and w is the weight of the barrel in lb. (usually neglected). Only nine-tenths of this result should be taken in practice. Another rule of thumb is buoyancy in lb. = contents of the barrel in gallons × 10.

Barrels are made up into piers by lashing, bung upwards, to spars, as shown in **3** and **6**. These piers are treated in the same way as pontoons. The lashings *must* be made tight.

Shore Ends. If the water-level be fairly constant and the banks be quite low, the baulks of the inshore bay may rest on a timber sill bedded in the ground; if the banks are high, an approach road will have to be cut through. The slope of this and the end bay must never exceed 1 in 7.

In tidal waters, shallow near the banks, the inshore piers may be allowed to ground, provided that the 1 in 7 slope is not thereby exceeded, and that the bottom will not injure the pontoons. For this purpose barrels are preferable, and should always be placed near the shore if there are both barrel piers and pontoons in use in one bridge. If the 1 in 7 slope would be exceeded by this method, owing to the steep slope of the river-bed, a long gangway may be used. The bridge would thus be available for infantry, although impassable for animals except at high tide. A better arrangement is got by the use of trestle-piers, which float at high water, and have their length arranged so that when the tide falls they ground in succession, taking the weight of the bridge off the boats on to themselves [**11**].

These trestles can be improvised. The service *Weldon trestle* is carried for shore ends, having a transom which can be raised or lowered by a differential chain tackle as the tide varies. The superstructure is the same as for pontoons. If the river is too deep for the use of trestles at all, the question becomes very difficult. No definite suggestions can be given, but the site should be avoided if possible.

A very rapid method for forming a two-plank bridge for infantry in single file is shown in **7** and **8**; anchors are required as for all other floating bridges, or each barrel may be secured by lashings to a cable stretched across the river.

Pier heads can be made with service pontoons, one to two bays being pushed out from the shore, and properly moored.

A *flying bridge* consists of a large boat, or pontoon, or barrel raft set at an angle to the current, made fast with a long cable to some fixed point, such as another boat, moored in the middle of the stream well above the proposed point of crossing. By attaching the cable to the raft by a sling in a suitable place, the current will force the raft across the river [**10**].

Strength of Spars. The strength of rectangular spars may be calculated thus for cross breaking: Let w be the weight per foot run on the spar, l be the distance in inches between the points of support, and b and d the breadth and depth of the baulk available for use (*timber, ordinary fir*), then:

$$\frac{wl^2}{8} = \frac{12}{6} \times 1200 \times bd^2$$

For example, to test a timber baulk $3\frac{1}{2}$ in. × 6 in.; how much will it carry across a gap of 15 ft. 9 in.?

Substituting in the formula, we have:

$$\frac{w \times 189^2}{8} = \frac{12}{6} \times 1200 \times \frac{7}{2} \times 6^2$$

$$\therefore\ w = 70 \text{ lb. per foot run.}$$

Therefore, if required to carry infantry in fours at 560 lb. per foot run, eight baulks will be used. Compare the fact that five of the proper Kauri pine pontoon baulks will suffice.

For round spars, let D = the mean diameter; calculate as for a rectangular beam, taking b and d as equal to D, and multiply the result by $\frac{6}{10}$.

Trestle Bridges. The simplest form of bridge in most cases, and the only one for railway work, is the *trestle bridge*. The river must necessarily not be too deep. Figure **12** shows a simple framed trestle for railway work; modifications of this, subject to loads given above, will do for road bridges.

The governing factors in design are the need for rapid construction and the nature and paucity of materials and labour available.

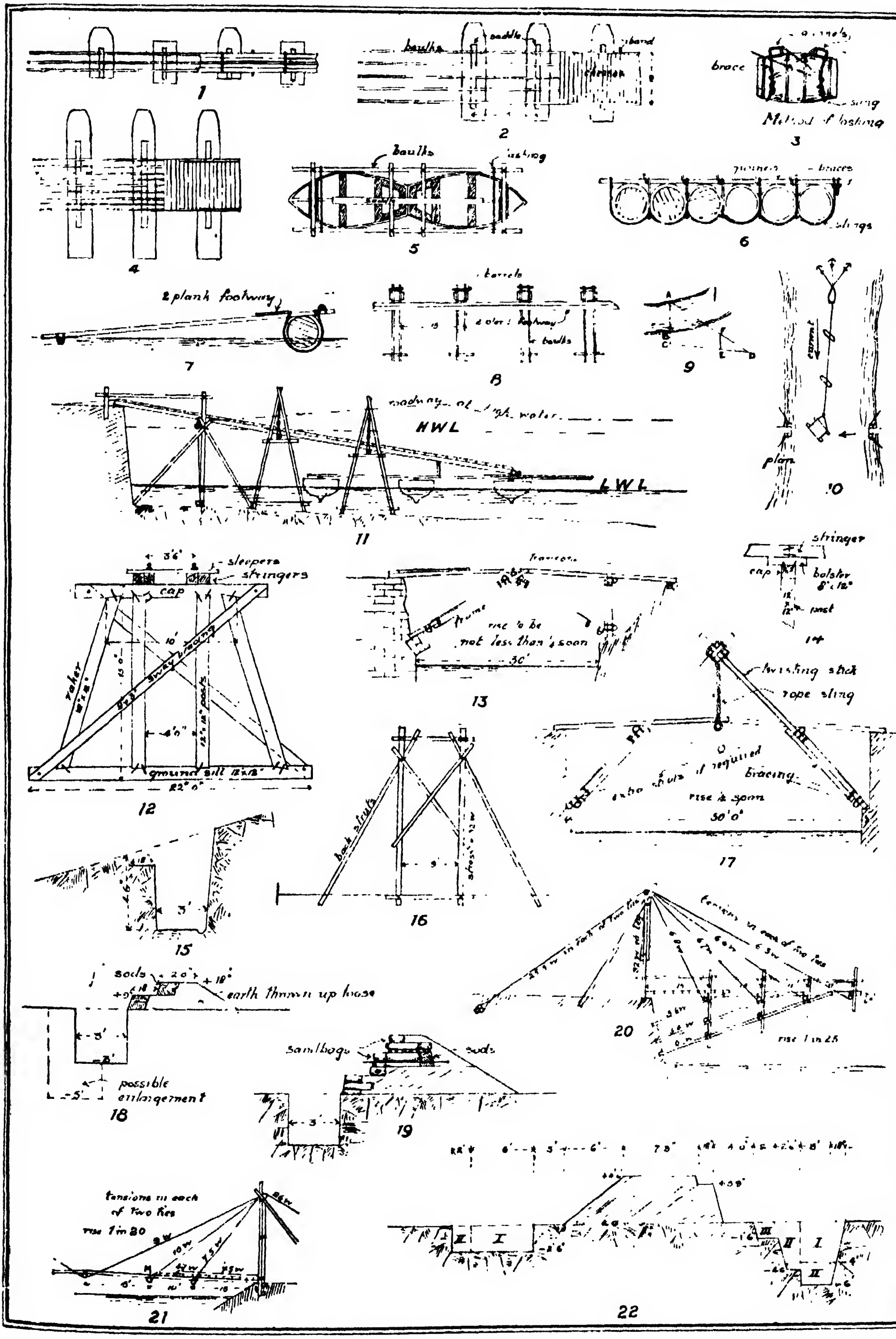
Sleepers on the bridge should be placed 1 ft. to 2 ft. apart, or closer, so as to distribute the weight.

Stringers, or rail-bearers, extend from one trestle to the next; the length of timber available for these will usually determine the spacing of trestles. Timber baulks, rails, rolled steel beams, or trussed timber beams may be used; any number of stringers are permissible; for timber baulks, the number is usually four placed two under each rail. Try to get stringers long enough to span over two trestles, and let them break joint on alternate trestles. If there is only a single stringer under each rail, use a bolster to get a bearing [**14**].

Stringers should be given a 1-in. check over trestle cap, and be spiked, bolted, or dogged to it. Timber baulks are suitable up to spans of 15 ft. to 20 ft. Four 12 in. × 12 in. baulks will do for a 15 ft. spacing of trestles for all locomotives at low speeds. The sleepers are spiked to the stringers.

Rails are good for short spans (such as broken culverts), laid close together side by side; the ends of the rails should be embedded in the ground under the permanent way, if possible, at each side of the gap. Five rails (steel, 56 lb. per yard) under each rail will carry all engines over an 8-ft. gap.

To calculate timber stringers, consider the heaviest pair of engine wheels as placed at their centre, and let their weight be W on each wheel in lb.



MILITARY ENGINEERING

1. Light bridge **2.** Medium bridge **3.** Method of lashing **4.** Heavy bridge **5.** Pier of boats **6.** Barrel pier **7.** Section of light infantry bridge **8.** Plan of light infantry bridge **9.** Method of measuring a river **10.** Flying bridge **11.** Tidal ramp **12.** Simple trestle **13.** Single lock bridge **14.** Bolster **15.** Trench where no command is required **16.** Shore frame for tension bridge **17.** Single sling bridge **18.** Fire trench **19.** Fire trench with head cover **20.** Strutted tension bridge **21.** Tension bridge without struts **22.** Section through parapet, showing reliefs

23. MEDIUM PONTOON BRIDGE

Then, using same symbols as given above,

$$\frac{W \times l}{4} = \frac{1200\ bd^2}{6}$$

For example, let the span be 15 ft. Let 7 tons be the heaviest *wheel* load. Then, substituting

$$\frac{7 \times 2240 \times 15 \times 12}{4} = \frac{1200\ bd^2}{6}$$

$\therefore bd^2 = 3428.$

Assuming that two baulks will be used, then bd^2 for each $= 1714 = 12^3$ (nearly). Therefore, two baulks 12 in. × 12 in. will do under each wheel.

Trestles. Framed trestles are made in one panel up to 20 ft. to 30 ft. high [12]. Above this, make them in two panels—that is, with a horizontal member half way up, and a double set of cross-bracing. A convenient spacing for trestles is 15 ft. The posts may be 12 in. × 12 in. or 10 in. × 12 in., the cap 12 in. × 12 in., and the sway bracing 9 in. × 3 in. or 12 in. × 3 in. The cap is drift-bolted, or dogged or spiked to the posts. Dogs are bars of iron 18 in. long pointed at the ends, and bent round into a flat ⊔ shape; they are driven into adjoining baulks of timber to hold them together.

For trestles up to 6 ft. high, use four vertical posts; above 6 ft. the outer two should slope; the inner two should be underneath the rails. There is no need for sway bracing for trestles under 12 ft. high. Place the trestles in position with their tops as nearly level as possible; the exact levelling up should be done by wedging after the stringers are in position. The base of trestles must be anchored against a serious rush of water. When the bottom is soft, trestles are sometimes built on piles; these would be cut off level after driving. They are slow and rarely used. Figure **24** shows a trestle pier bridge over the Zand River, South Africa.

Crib Piers. A substitute for a trestle is a *crib pier*, made by piling sleepers crosswise on top of each other. These crib piers are very wasteful of sleepers, but are quickly erected by a party of infantry; a very large number of men can be employed at once carrying the sleepers. They block up a lot of waterway and must be filled with stones and spiked if required to resist a serious flow of water. For erection in water, construct the lower portion on shore, spike it together and floor in the bottom; float it off to the right place and sink it by filling with stones. The maximum height for crib piers is 25 ft., and they are most useful for crossing dry gaps on land.

All bolts should be about $\frac{3}{4}$ in. diameter; drift bolts are $\frac{3}{4}$ in. square or round iron with a head at one end; they can be made on the spot with a field forge.

Smooth bolts hold better than jagged in timber, and round have 25 per cent. more holding power than square. The holding pull of a round bolt in fir is 300 lb. per square inch of surface of the bolt.

All bolt holes should be bored $\frac{1}{8}$ in. smaller than the bolt.

The best foundation for a trestle on rock is got by cutting the rock level, or making it up with concrete.

On ordinary soil, rest the sill of the trestle on a platform of sleepers cut in half.

On sand, put in a long, low crib pier of sleepers, floored underneath. For mud, piles are necessary. Where the water may cause scour, surround the base of all trestles or piers with piles of large, loose stones.

Frame Bridges. For a span where the water is too deep for a trestle bridge *frame bridges* may be convenient.

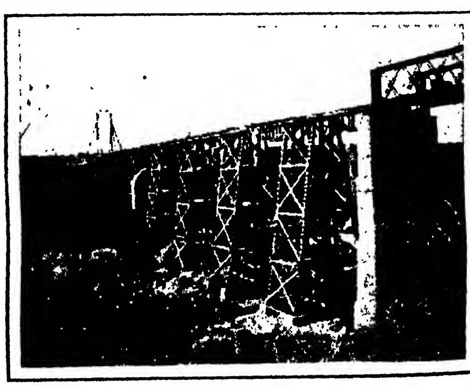
Figure **13** shows the remains of a demolished arch and a single lock bridge in position. Two heavy frames are made, one on each bank, and when good footings have been obtained, they are lowered forward until they meet and lock as shown. The trestle on the right is slightly narrower than that on the left, so as to lock inside it. A transom is placed across and road-bearers are laid with chesses or planks on top in the usual way. Calculations for road-bearers are the same as for pontoon baulks, except that they are usually round. Such a bridge is suitable for a 30-ft. gap and is very rapid if made by skilled labour.

For bigger spans up to 50 ft., a single sling bridge can be used, as shown in **17.** There are four gaps of 12 ft. 6 in. for the road-bearers to span. The great difficulty with these bridges is to get good footings for the base of the trestles, and they require very large spars of good quality.

Tension Bridges. For spans of 60 ft. and upwards, a tension bridge is more suitable; its strength largely depends on cables, which are easy to transport.

A strutted tension bridge is shown in **20** for 100 ft. span and a roadway 6 ft. wide in the clear; if required for a smaller span one set of ties on each side of the centre can be omitted, which will reduce the span to 78 ft. The loads on all transoms except that at the centre are carried by the tension of a pair of ties and the compression of a pair of struts.

The central transom is carried by a pair of ties. The height of the pier at each abutment should not be less than one-fourth the span. The vertical frames are made as in **16.** The uprights may be made of two spars, one shorter than the other with the top transom resting on top of it.



24. TRESTLE BRIDGE, ZAND RIVER, SOUTH AFRICA

The frames are raised with back struts, and back guys are fixed to the anchorage. In loam, anchorages may consist of one large or three smaller buried logs; they should be placed well back from the pier; three 10-in. logs, 15 ft. long, would suffice if 3 ft. below ground.

A tackle from the head of each frame is used for pulling out the struts of the opposite abutment into position; the ties are secured to the transoms, and the roadway is laid outwards from both banks. Steadying guys should be brought from the ends of the central transoms, crossed under the roadway, and brought to the bank, where they should be hauled taut and secured well to the left and right of the bridge to prevent sideways oscillation.

The stresses in the different guys are marked in **20**, and are for a single tie—*i.e.*, one on either side of the roadway.

The strength of cables is found thus: Let W be the breaking weight in tons, and c be the circumference of the rope in inches. Then for hemp rope $W = \frac{1}{3} c^2$, and for steel rope $W = 2{\cdot}5\, c^2$.

This value should be divided by a factor of safety of 5 or 4 according to the condition of the material.

A tension bridge can also be erected without the timber struts underneath.

Figure **21** shows such a bridge designed for an 80-ft. span. The loads are supported by the ties and by the resistance to compression of the outer road-bearers, which here take the place of struts. The footings for these must be carefully prepared to take the thrust. The outer spars should be in one piece long enough to extend beyond M in **21**.

25. CANTILEVER BRIDGE, CHITRAL

The ties should be tightened up so as to lift the bridge well up above its proposed camber of 1 in 20. When loaded it will soon come down again owing to stretch.

Suspension Bridges. *Suspension* bridges are suitable for large spans, and, depending as they do on cables for their strength, are very portable; they are specially suited for light infantry bridges.

They are of three kinds—namely, the common form, in which the roadway, consisting of transoms, road-bearers and chesses, is suspended below the cables by slings; the ramp suspension bridge, in which the roadway rests for the most part directly on the cables, and consists of chesses only, road-bearers being required for only one bay at each end; and the trestle suspension bridge, in which the cables are quite low, and the roadway consists of chesses and road-bearers supported on trestles which rest on the cables. For the first type, the cables rest on timber frames on each bank. The anchorages must be carefully formed, the pull of the anchor cables being kept flat. From the cables slings are suspended at 10-ft. intervals carrying the transoms: the road-bearers are laid on these, followed by the chesses. The usual *dip* of the cable is $\frac{1}{10}$ to $\frac{1}{12}$ of the span. In erection it should be hauled up well above its final position to allow of stretch. A stretch of 1 in. in a cable gives an increase of 2 in. to 3 in. in the dip. The length of slings can be worked out beforehand, and they can be fastened to their transom and prepared on the bank before sliding them out along the cables. Let y = length in feet of the sling required, and suppose it is intended to be fixed x ft. from the centre of the span. Let a be the span, and d the dip in feet. Then

$$y = \frac{4d}{a^2} x^2$$

Lateral guys must be brought to the banks, well out to the right and left, to steady the bridge against swaying in the wind.

The trestle suspension bridge has the advantage of requiring no timber frames at the banks to carry the cables, since a log buried in the ground as a sill will suffice; but it is more difficult to construct and takes a good deal of timber.

The stress in the main cables is found thus: Let w be the load on the bridge per foot run in lb., and let T be the maximum tension in all the cables together in lb. (occurs at the centre); let a and d be as before.

Then $T = \frac{wa^2}{8d}$ lb

The cables may be of rope or steel wire, one or more being used at each side as required; or they may be made of twisted telegraph wire.

This latter expedient is very useful for light infantry bridges two planks wide. Two lengths of ordinary wire fence, posts and all, may be slung across the gap, with their lower edges fastened together so that they hang in a V-shape. A wide plank is laid along the bottom between them, and infantry can then cross in single file at two paces distance. There are many other military bridges, but the commonest have here been dealt with. Figure **26** shows a suspension bridge.

Cantilever Bridges. *Cantilever* bridges are very much used in India, their chief advantage being that they can be built out from both banks until they nearly meet; the gap is spanned by road-bearers; they require no cables or trestles.

The principle consists in using several layers of long spars projecting out over the gap. Their centres rest on a ground sill, in the case of the lowest layer, or a transom in the case of upper layers; their inshore ends are anchored down with wire to a buried anchorage or are weighted down with a mass of stones and earth. Figure **25** shows such a bridge.

Aerial Cableways. *Aerial cableways* are of frequent use in steel bridge construction: they can also be improvised with advantage for slinging stores across a ravine or river, or from a ship at anchor to the shore.

The strain of the cable can be found as for suspension bridges. A steel wire cable is usual—and its size can be selected by the rules given above (Tension Bridges).

The cable is carried over a trestle at each end and passes on to an anchorage in the ground. Strong trees or the masts of a ship can sometimes be utilised

to fasten the cable to. A cradle, or merely a hook, running along the cable by means of a pulley-wheel constitutes the traveller, and hauling lines must be supplied to work the traveller to and fro. Such a device would be most useful where waggons have to cross a river by means of a bad drift with a steep pull out the other side; they can be lightened, half their loads being sent across overhead.

Roads. *Roads* must be 10 ft. wide to take a single stream of traffic; 6 ft. will do for infantry in file or pack animals. The gradient must not exceed 1 in 10 for long inclines, although for very short bits with level at either end, 1 in 7 for artillery or 1 in 20 for infantry is permissible. For making a road, lay out the centre line with pickets; it should be as straight as possible, especially avoiding sharp curves on a gradient.

Drains must be cut along both sides and underneath the road at intervals to get rid of water; loose earth should be removed. If metal is to be applied, large stones should be spread as a foundation, and above this should come a layer of smaller stone 3 in. or 4 in. thick. A thin top layer of gravel or other binding material should be rolled in or rammed, plenty of water being used. For rough roads the camber, or curved shape, should be much exaggerated; a road, once a hollow has formed in the middle, will never last, and can never recover its shape. If gravel is the sole metalling material, mix it with loam to bind the pebbles together.

A road on the side of a hill is made partly by cutting and partly by embankment, unless the hill is very steep, in which case it should all be cutting.

The ground on which the embankment rests may have a step cut along it to prevent the bank slipping; the surface of the road should slope well inwards towards the hill, catchwater drains being made above.

Water Supply. Each man requires 3 gal. to 4 gal. of water per diem for drinking, cooking, and washing; 5 gal. or 6 gal. should be given if possible. If washing can be done in a river, 2 gal. is enough Every horse or draught animal requires 8 gal. to 10 gal. Horses drink 2 gal. at a time, taking five minutes over it, and occupying 4 ft. of space laterally.

Water supply may be from springs, streams, rivers, wells, or lakes. If a camp supply be from lakes or streams, separate places must be marked out for drinking, animals, and washing, the first being up-stream of all, and the others in the order named. Red, white, and blue flags should be planted, and policemen posted to ensure careful observance of these rules. If it is necessary to dip vessels in the stream, arrangements should be made to prevent the bottom being stirred up; a sunken barrel is a good device; dipping should be forbidden if pumps are available.

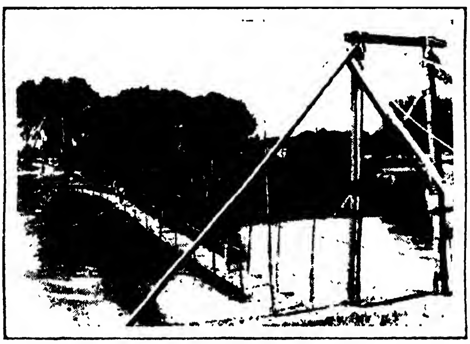
If the supply is from springs, these should be opened up and surrounded with a low puddled wall to keep out rain-water; arrangements should be made to catch the overflow in barrels, or canvas tanks sunk in the ground. Springs are rarely sufficient in themselves to supply a camp.

The flow of a stream may be gauged thus: Select some 12 yd. of a stream where the channel is fairly uniform; drop in any sort of float, and obtain the surface velocity of the water in feet per second. Take the breadth and average depth of the stream; multiply this sectional area by four-fifths the surface velocity, and this gives the yield in cubic feet per second.

All drinking water should be boiled if it is in any way doubtful. Filters are impracticable on service; 6 gr. of alum per gallon will precipitate all sediment in water, and a little permanganate of potash acts as an antiseptic. The water should just look pink-tinted.

Field Fortification. *Trenches* divide themselves into "fire," "communication," and "cover trenches." Dealing with the first, its site, extent, shape, and profile must depend on many considerations—namely, the tactical condition of affairs, on whether the trenches are intended for the defence of a position or as cover to an attacking force; on the force to be protected, on the time available, and on the nature of the ground and the enemy's guns.

Siting of Trenches. The principles governing the proper siting of trenches belong to the subject of tactics and choice of positions, but a few unalterable principles are given. Trenches must fit the force they are to cover, must have a good, clear field of fire for at least decisive rifle range, must be concealed from view, and should have easy means of reinforcement and support. These principles outweigh all others. In defending a line of hills, fire trenches may be placed at the top or the foot of the slope. A high position has the following advantages: good moral effect, as the defenders feel safer, reinforcement from behind the hill is easy, a better view is obtained of the enemy; but the fire from the trenches is inclined to be plunging, the position is more conspicuous, and the attacking infantry can be supported by their artillery firing over their heads until the last moment.



26. SUSPENSION BRIDGE

Nearly all hills are convex at the top and concave at the bottom. For steep hills, put the fire trenches at the foot, in the convex slope, just about where cultivation ends. This ensures a good flat field of fire, but sacrifices efficient reinforcement from supports. If, however, such a position would be too much overlooked by surrounding high ground, it is better to go back to the reverse side of the top of the hill. From here the forward slope of the hill will be invisible, but should the attacking infantry gain the top of the hill it is met with a withering fire at close range. Support in such a position is easy. On gentle slopes the forward crest line is the most suitable place. Trenches should be either in front of or behind sky-lines, as seen by the enemy; they should usually follow the contour of the ground; freshly turned earth should be covered or scattered.

Profile of Trenches. Trenches may have a parapet 12 in. high for fire lying down, 3 ft. for fire kneeling, or 4 ft. 6 in. for fire standing. The latter should be provided if time allows. A trench should never be narrower than 2 ft., 3 ft. being the usual width. This enables men to sit in the trench well

under cover, which is most desirable. Figures **15**, **18**, and **19** show three types of trench.

The *thickness* of the parapet depends on the penetration of a rifle bullet, the effect of high explosive common shell being ignored. Two feet is the minimum at the top. The exterior slope is usually the natural slope at which the earth will stand: the interior slope should be as steep as possible, usually 4 in 1; it will generally require revetting, as explained later.

The *command* or height of the parapet above the surrounding ground is governed by the visibility of the ground in front. One yard per man gives a suitable length for fire trenches.

As the direction of the attackers' fire will not always be from the front, all trenches must be protected from oblique and enfilade fire, by breaking them up into short lengths with *traverses;* these, consisting merely of earth banks, should cut the trench up into lengths of 8 yd. to 10 yd., their frequency depending on the degree to which the trench is overlooked or commanded from the flanks, etc. All trenches should be drained by making occasional sump pits, into which rain-water will collect, and can, if required, be baled out. If trenches are intended for long occupation, they may be undercut to give additional cover.

A certain number of picks and shovels are carried by every R.E. and infantry unit: the number is laid down in field service manuals. Each unit, as a rule, digs its own trenches under R.E. supervision.

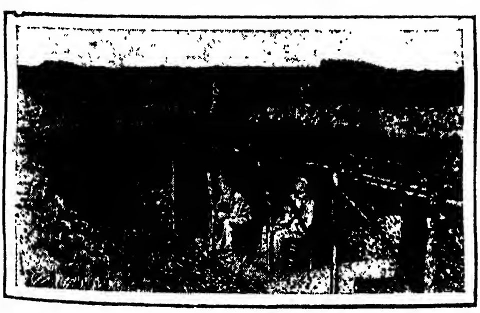
Making a Trench. The proposed trench is first laid out on the ground with a tracing tape along the crest-line. From this line are measured the cutting lines at front and rear edges of the trench. These are marked with tapes, and the tape is removed from the crest-line. Simple works, such as shelter trenches, are, as a rule, marked out by spit-locking their cutting lines on the ground with a pickaxe.

If the section of parapet is complicated, "profiles," or forms made of light wooden battens nailed together in the required shape, are erected at all angles of the trench, and at every 30 ft. in straight faces.

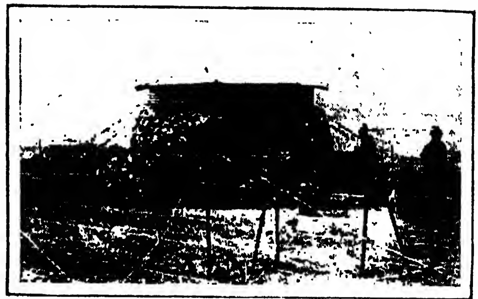
The working parties march up to the work, pick up their tools, and extend along the cutting-lines. Men should be spaced from 5 ft. to 10 ft. apart—4 ft. cramps them—and must use their pick facing the front. Working sideways is dangerous, and likely to make noise from clanging of tools.

Men work best in short *reliefs*, say four hours actual digging. In easy soil six hours may be resorted to. In heavy soil increase the number of reliefs rather than the length.

Most careful arrangement must be made to ensure rapid distribution of working parties. Each man's task should be marked out for him before if possible. A man can dig 30 cubic ft. per hour, or 20 cubic ft.



27. REDOUBT



28. BLOCKHOUSE ON LINES OF COMMUNICATION, SOUTH AFRICA

if continued over four hours in ordinary soil; in very soft ground allow $\frac{3}{2}$ this, or in heavy soil $\frac{2}{3}$. This includes 12 ft. horizontal and 4 ft. vertical throw. Men work better on task work than by time. When their task is done the men should rest. When the throw exceeds the limits stated above, extra shovellers become necessary; one per two or three diggers will suffice. Each relief should, if possible, leave a vertical face for the next to work on. Figure **22** shows the work of each relief on the parapet of a redoubt; the trench in front is required to provide enough earth to give the requisite command of the parapet.

It will be seen that the first relief (four hours), with tasks 5 ft. wide, do 80 cubic ft. in the trench and 75 cubic ft. in the ditch in front. No. 2 relief do $77\frac{1}{2}$ cubic ft. in the trench and only 25 in the ditch; these men go on filling sandbags etc., for head cover. No. 3 relief finish off the digging and give nearly all their attention to head cover.

Revetments. When any bank of earth is required to stand more steeply than its natural slope, it must be revetted with some other material. In first cutting the ground for a trench the turf should be taken off in sods, which are very good, and should be laid, grass down, in two rows of stretchers and one of headers; the steepest slope at which they will stand is 3 in 1. Two builders and three cutters and carriers can cut and lay 100 per hour. Other revetting materials are boards, wattle hurdles, gabions, canvas sheets, brushwood, stones, sandbags, and sacks.

Boards would be placed longwise at the back of the parapet, being held in by occasional wood posts having their lower and upper ends anchored back by wire to logs or stones buried in the parapet. Brushwood could be treated in the same way, the interval between supporting posts being smaller. The brushwood should be packed in as the parapet grows, or it may be made into *fascines*, or long bundles, 18 ft. long, and an average diameter of 9 in. These are tied round with wire every 18 in. as tightly as possible.

Hurdles are a more convenient revetment if found ready made. They are anchored back to logs buried in the parapet by wire as before described. If made on the spot they take three men $2\frac{1}{2}$ hours each, and are 6 ft. long by 2 ft. 9 in. across.

Stones are not good as they splinter a great deal, but if safe from bullets they make a quick rough revetment.

Sandbags are nearly always available. They should be filled four-fifths full of earth and be tied up. They measure 20 in. by 10 in. by 5 in. when filled. For revetments they are built into the rear face of the parapet in alternate layers of headers and stretchers; a bag laid lengthwise to the parapet

is called a *stretcher*, and one laid across, a *header*. The tied ends should always be buried. Two builders and three fillers can fill and lay 70 bags per hour. Corn sacks or others can be profitably utilised in the same way.

Providing *head cover* consists in building the parapet up 18 in. to 2 ft. higher than firing level, and making loopholes at 3 ft. to 4 ft. 6 in. intervals. It is not essential if time is scarce, but is most desirable on account of the immense moral support it gives to the defenders, in addition to actual protection. This latter is almost counterbalanced by the visibility which loopholes are almost bound to occasion, and the restriction of the defenders' view and line of fire. To give lateral fire, loopholes must be splayed, the narrow end outwards; they are 10 in. high, 6 in. wide on the outside, and 20 in. inside.

Sandbags are usually employed for this purpose; two bags are laid on the parapet at each side of the loopholes, splayed to the proper angle; some small sticks, etc., are laid across their top, and more bags are laid on them, one layer of headers, and one of stretchers [**19**].

Communication trenches afford means of reinforcement from the flanks and rear under cover. They would not be provided unless reinforcement has to be done over a long stretch of open fire-swept ground. They are merely plain trenches approaching the front diagonally so as to be covered from fire.

Cover trenches are for the supports to rest in. They require no loopholes, but should have a parapet in front and rear to provide against back-blast from high explosive shells. They also serve as a rallying point if the first line is temporarily driven in.

Redoubts. A *redoubt* is a work entirely closed by defensible parapets; it is usually rather conspicuous, and not so well suited to the defence of extended positions as are trenches, but it breaks up the cohesion of the attack, is very strong, and gives great moral strength to the defenders, who know that their flanks are secure and that their commanding officer intends to hold on to the last. In the case of surprise or night attack, liable to come from any direction, the redoubt is invaluable. The *trace*, or shape, of a redoubt, depends on the garrison and the direction in which the strongest fire is required. Regularity of trace is of no importance. A redoubt must have no dead angles; when firing through a loophole a man cannot conveniently fire more than 15° to one side or the other. This in the case of a rectangular redoubt would leave a large undefended area at each corner. It is avoided by blunting the angles of the rectangle (radius 20 yards), and this is perhaps the commonest trace of an isolated redoubt. A circle is not so good, as it has no strong fire in any direction.

The entrance should be on the least exposed side, and should be well traversed, and closed at night by some obstacle such as tangled wire.

Reverse cover is often required to prevent bullets aimed at one face hitting the defenders of the opposite face in the back. This must depend on the command and position of the redoubt, and the height of the enemy's position from which he is firing. Traverses also may be wanted. Beyond this the construction of a redoubt is exactly similar to that of good trenches, carefully made profiles being required. For redoubts of a somewhat permanent nature, such as would be required in the protracted defence of a position, good splinter-proof overhead cover must be given inside the work for men not actually engaged on the walls. The height and size of this cover is a matter of time and material. The simplest consists of a timber framework on which is laid brushwood [**27**]. This is covered with sods or sandbags and earth, to a thickness of 12 in. to 18 in.

Field of Fire. *Clearing* the foreground in front of trenches is important, so as to give the defenders free use of their weapons within effective ranges. Growths that block fire or impede the view must therefore be removed, but such natural obstacles as merely break up the enemy's formation of attack should be left standing or be improved. Cut down hedges parallel to the front, but leave those perpendicular to the front. The same applies to walls. One man can cut down 2 yd. of thick, quickset hedge in 10 to 15 minutes. Large trees are better left, as they give less cover standing than when felled. Brushwood must be cleared wholesale, if at all: the outer fringe may be left standing with advantage; it will not usually affect the fire of the defence.

Hollows in the ground in front must be filled up with earth or denied to the enemy as rallying points by filling them with felled trees, or mines.

Obstacles in the field of fire are always provided if possible, and are of two kinds: (1) To check the enemy's advance, and delay him under the defenders' fire; and (2) by passive obstruction to compel the enemy to choose other certain lines of attack.

For the former, the obstacles must be under close rifle fire, say 50 yd.; they must give no cover to the enemy, must not be easily damaged by artillery fire, and must not be easily removed.

Abatis, or tree entanglements, are made by felling trees and pinning them down to the ground, with their tops towards the enemy, and their stems resting in a trench. The branches may be pointed with a hand-axe, and barbed wire may be tangled among them.

A stiff hedge, felled by cutting the stems half through, and picketed down, is very effective and rapid.

A wire fence across the front is useful as an alarm at night, if hung with empty tins with a pebble in them.

Thin trip wires fixed on posts about 12 in. off the ground, with their ends tied to a friction tube, are useful as alarms; when kicked or walked on, they explode.

Wire entanglements form the most efficient obstacle. The low wire entanglement is made about 12 in. to 18 in. off the ground, being strung tightly between posts placed chequerwise, 6 ft. apart. It is not now much used, except in fords. High wire entanglements made with barbed wire are, however, excellent. The posts are driven 6 ft. to 7 ft. apart, and are 4 ft. high. Such an entanglement is shown in **28**. It takes one man three minutes per square foot of ground covered.

Land mines, or fougasses, are now practically a thing of the past for field fortification.

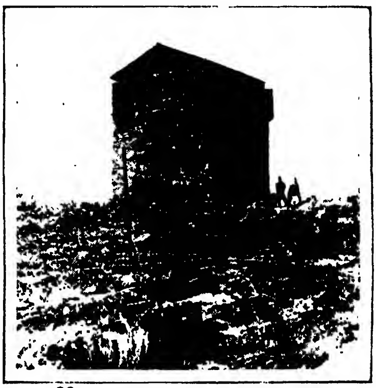
The second order of obstacles, such as a stream or marshy ground, can often do with improvement. Remove all bridges, entangle the bed of the stream or throw cut trees in.

Blockhouses. *Defensible posts* are frequently provided along the lines of communication to protect them, at important points, such as railway stations, camping grounds, bridges, etc. They are usually very small, garrisoned by a handful of infantry. They may be liable to attack from all sides, and generally take the form of one or more blockhouses. Figure **28** shows the type that was

most used in South Africa. A large hollow cylinder of curved corrugated iron is bolted together, 4 ft. high and 13 ft. 6 in. diameter. It is placed whole on the correct spot, and a rough stone wall is built up round it. If stones are not available, a second envelope of corrugated iron may be made, 18 ft. 6 in. diameter. This is placed concentrically outside the other, and the annular space is filled with earth. The earth is got from a trench dug round the block house. When this earth or stone wall is finished, the top is levelled off with a course of filled sandbags, and on this is put a cylindrical hollow screen, consisting of two rings of corrugated iron, 5 in. apart. This has loopholes made in it all ready. The screen is filled with carefully rammed gravel or broken stone, and on top of it is placed a light roof for protection against weather. The entrance is through a small square hole in the side, or by a passage leading from the surrounding trench up through the floor of the blockhouse. It is surrounded with a belt of high wire entanglement. The sentry at night is stationed in the trench, and anything approaching is seen against the sky. These blockhouses take six sappers and 20 infantry about eight hours to construct. The garrison is one N.C.O. and seven men.

Stone Blockhouses. Another type of blockhouse, built of masonry, is shown in **29.** This has three tiers of fire provided, with two *machicoulis* (overhanging) galleries for fire downwards on to the attackers.

The loopholes consist of ⅜ in. steel plates, 24 in. by 12 in., with a 5 in. by 3 in. hole in the middle. These are built into the masonry and give plenty of splay for lateral fire.



29. MASONRY BLOCKHOUSE

Other defensible posts sometimes occur where isolated depots of stores have to be guarded, or where a village or well-marked hill projects out in front of the general line of a defensive position that is to be held. In such cases, any existing building, if not exposed to artillery fire, may be utilised.

Defending a House. The defence of a house is common in history, and may recur, especially against savages. All openings must be closed up and made bullet-proof; windows and doors should be built up with sandbags or screens of corrugated iron and gravel. Loopholes may be left in these, and others must be knocked through the walls. Doors, even if they cannot be made bullet-proof, must be barricaded. Loopholes must be high enough above the ground (7 ft. to 8 ft.) to prevent the enemy rushing up and firing through them; the defenders can reach them by using chairs or planks on barrels, etc.

Communication from one room to another must be secured by knocking holes through the walls, if necessary. All inflammable material outside should be removed, and loose earth should be collected in the rooms for fire extinction. The house should be surrounded with wire entanglement or other obstacle, if time permits.

Village Defence. Villages may become defensible posts on a large scale. They are rarely worth defending. Under artillery fire they are practically untenable, and they use up a lot of men. If they are to be held, the foregoing principles all apply. A good central building should be selected as a keep, where a final stand can be made, and both first and second lines of defence should be prepared. Lateral communication from one section to another is important.

Siege Works. The regular siege of a fortress comprises the following stages: the investment and entrenchment of the besiegers, the establishment of heavy siege artillery, the infantry approach, by sapping, into the first and second parallels, the further approach by mining, and the final assault.

The line of investment is drawn in as close to the fort as the defenders' fire will allow in the ordinary way, and is there entrenched. From this trench, at several specially selected spots, a *sap* is begun.

This consists of a deep trench run out diagonally towards the fort, in such a direction that the defenders of the fort cannot shoot along it. When it has gone some way, a trench is cut out in both directions from its head, and is called the *first parallel*, and troops are moved up into this. From here, more sapping is done, into a second or even third parallel. By this time, the proximity to the enemy is such that further sapping is out of the question, and *mining* has to be resorted to.

Shafts are sunk, and galleries are driven towards the enemy; heavy charges are exploded in the mine to form craters in the ground. The infantry dash forward and occupy these, and so on, until near enough to breach the walls of the fortress and deliver the assault.

In sapping, all work must be done under cover. The trench is 3 ft. wide and 5 ft. deep. The excavated earth is thrown out of the trench towards the enemy; the head of the sap is protected by a steel sap-shield, 2 ft. 6 in. by 2 ft., with two detachable legs, resting on the level ground. Only two men can work at the sap-head with picks, and two shovellers help them behind.

The soil should be thrown well forward of the sap-head, to get efficient cover to the workers.

Mines. When *mining* has to be resorted to, a vertical shaft is sunk, 4 ft. 4 in. by 2 ft. 4 in. in size. One N.C.O. and four men is the best working party. If the soil requires it, a shaft is lined, as it proceeds, with timber frames, which are an article of store. When the required depth is reached (15 to 20 ft.), a common gallery is driven towards the enemy, 5 ft. 10 in. by 2 ft. 4 in. in size. This is lined with timber sheeting or special frames. One N.C.O. and four men is the best allowance, with an extra man for shovelling, to every 20 ft. advance underground. Recesses should be provided every 30 ft. along.

If no opposition is experienced, these galleries will be driven up as close to the fort as possible: if not, right into the ditch, or under it. This occurred in the Japanese siege of Port Arthur.

But, underground galleries built in masonry generally form part of the defence of a fort; from these galleries an energetic defender will drive countermines with a view to preventing the progress of the attacker, by blowing in his galleries or, after he has formed and occupied a line of craters, by blowing up the troops in them. Countermines are in every respect similar to mine galleries. Mining trucks and light rails are invaluable for removal of soil. Intercommunication, ventilation

and light must be provided, and the most accurate plans are essential.

Luminous paint on sheets of zinc gives enough light for the powder chambers or gallery heads. Listening is the surest way of detecting the approach of an enemy's gallery; during this listening, all work must be stopped. Mine charges must be tamped, and the gallery should be closely packed for a distance of one and a half to twice the line of least resistance (depth below ground) of the charge. Filled sandbags form the best tamping, though loose earth will do.

Demolitions. The explosives used for *demolitions* are broadly of two kinds: powder when a steady upheaving effect is required, and guncotton or other high explosive when a sharp, cutting blow is necessary. Powder explodes by combustion, taking a very appreciable time for the formation of all its gases, whereas high explosives detonate (or decompose) in an instant.

Powder would be used in mining for making large craters or for bringing down large masses of earth or rock—as, for instance, in blasting a road in the side of a hill—whereas guncotton would be used for breaking up large boulders, destroying steel bridges, houses, forts or cutting down trees. The object of mines in siege work is to form a continuous line of craters parallel to the front, such that the attacking infantry can occupy them as cover.

Gunpowder is supplied in barrels of 100, 50 and 25 lb. Charges should be made up as compactly as possible in a waterproof bag. A service sandbag holds 40 lb. of powder. For destroying masonry walls, powder charges are calculated thus: let B = length of wall to be demolished in feet; let T = thickness to be demolished in feet; let C = charge in lb. Then, for a brick wall or the haunch of a brick arch, $C = BT^2 \times \frac{3}{2}$. This charge should be subdivided into smaller charges, placed about twice the thickness of the brickwork apart. For a wooden stockade allow 40 lb. to 100 lb.; for a fort gate, 200 lb. in one charge; for a stockade of earth between timber allow 70 lb. per 5 ft. run. In the presence of the enemy increase above charges by 50 per cent. Powder charges can be fired electrically or by safety fuse. The end of the safety fuse is cut off on the slope so as to expose the burning composition, and is placed well in the middle of the powder charge.

Explosives. *Guncotton* is carried wet in slabs of 1 lb. to $2\frac{1}{2}$ lb. weight; it can be cut up with a plain saw, plenty of water being used as a lubricant. Wet guncotton is absolutely safe and will not detonate with the ordinary detonator. Each slab has a round hole in it into which can fit a dry guncotton *primer*. If this dry primer be detonated it will also detonate all the wet charge, consisting of several slabs, provided that they are in close contact with each other. The dry primer is itself detonated by a detonator and fuse, or electric detonator. The charge must always be in close contact with the object to be demolished, and must extend across the whole length of the object to be cut. For applying charges to walls, stockades, or steel work, they should be made up carefully on a board, and can then be placed whole against the object. For cutting a brick wall up to 2 ft. thick allow 2 lb. per foot run; for a brick arch dig the earth roadway off the haunch and give $\frac{3}{4}$ BT^2 (symbols as before); for a brick wall over 2 ft., $C = \frac{1}{2} BT^2$; for a brick pier $C = \frac{2}{3} BT^2$; for a hardwood stockade, $C = 3\ BT^2$; to destroy a field gun use $1\frac{1}{2}$ lb. on the chase near muzzle, heavy gun 4 lb. at bottom of bore with water tamping; steel rail $\frac{1}{4}$ lb. against web; iron rail $\frac{2}{3}$ lb.; for iron and steel plate, $C = \frac{3}{2}Bt^2$, where t = thickness of plate in inches. For a blockhouse or frontier tower of stone and mud, place 20 lb. to 30 lb. in the middle of the tower, and block up all openings (doors). Trees and posts can be cut down by placing two or three primers in a 2 in. auger hole, or by surrounding them with a necklace of primers threaded on a wire, so long as each piece is in contact. *Cordite* can be used, but requires a guncotton primer to detonate it.

Dynamite is most suitable for blasting rock. One or two cartridges are exploded in a hole made with drills or jumping bars. Detonation is done with a commercial copper cap. Dynamite freezes at 40° F. and is then dangerous. It must be thawed before use by placing in a dry vessel standing in warm water.

Ignition. *Safety fuse* burns at 4 ft. per minute; it is waterproof; for use with a detonator it is cut off square and the end is inserted into the tube end of the detonator, where it is secured by pinching. The end for lighting is slit down the middle about 1 in., and a fusee is employed to light it. If the charge is some way below ground instantaneous fuse is sometimes used to save time, in combination with a short length of safety fuse. The detonator contains fulminate of mercury and should be handled with great care: it is an article of service equipment.

Electric firing is done by means of an exploder or batteries; the former is an article of service equipment. The batteries suitable are the Grove cell with constants 2 volts and ·1 ohm, and the Leclanché, constants 1·3 volts and ·25 ohms. The former is rarely available; the latter is carried by telegraph sections made up into batteries of six cells.

Two insulated wire leads are required leading to the charge: here they are connected to a special fuse in the case of powder, or a detonator in the case of guncotton. Electric firing is most useful when two or three charges are to be fired simultaneously or from a distance.

Balloons. *Balloons* are becoming more and more necessary day by day. The headquarters of the R.E. balloon companies are at Aldershot, where the factory makes all that is required. Military balloons are made of skin, and average about 12,000 cubic ft. in capacity [see article beginning on page 3977]. They are inflated with hydrogen gas, which is produced by the electrolysis of water. When empty, the balloon lies inside its car, in which state it would be carried in a waggon on service. When once filled, it is not easy of concealment, and its method of advance with troops would depend on military requirements; either it would be towed along aloft well out of danger, or hidden as well as possible close to the ground. Captive military balloons are employed for observation of the enemy's movements and to assist friendly artillery by discovering hidden targets. The observer, who is generally alone, sits in the wicker car and reports his observations by telephone on the ground.

MILITARY ENGINEERING *concluded; followed by* ARMS AND AMMUNITION

ILLUMINATION

Prep:ring the Vellum and Quill Pens. MSS. Decoration in Applied and Burnished Gold and in Colour. The Art of the so-called Dark Ages

Continued from page 6105

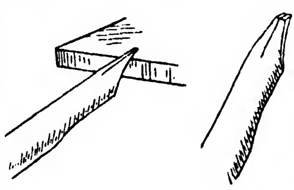
By G. A. POWNALL

THOUGH the word "illumination" is indifferently applied to all kinds of decoration upon the pages of books, it really implies decoration in raised and brightly burnished gold. Painting in colours generally accompanied it, but by no means always. Most Celtic MSS., on the other hand, are painted, but not illuminated. The idea of decorating the margins of text having originated, one may say, in Greece (although slight rubrication was practised in Egypt), and then spread through Rome to the rest of the Western world, one notices how much the earlier MSS. of different countries resemble one another, and how each branch developed along its own lines until several very distinct schools are found in the late fifteenth or early sixteenth centuries.

It was in the days of the Ptolemys that skins were first used for writing. Eumenes, king of Pergamus, aroused the jealousy of the then reigning Ptolemy by the celebrated library which he was then founding; whereupon the latter refused to supply him, as he had done till then, with papyrus. Eumenes then introduced the use of skins properly dressed for taking ink and pigment, thereby rendering himself independent of his Egyptian rival.

The Vellum and Ink. We now come to the practical side of the question, and the first thing to be considered is the surface of the vellum. Old vellum was prepared in a way which gave it a very beautiful surface, velvety to the touch and delightful to work upon. This is unfortunately a lost recipe. No manufacturer that we know of can get quite that surface.

Modern vellum has a shiny and at the same time absorbent surface which does not take ink or colour nicely, or anything else. For ordinary thick vellum (that is, neither Roman, slink, nor goat) the following method, homely though it sounds, is the best way of treating it before beginning work. Smear vaseline over a piece of rag and warm it so as to allow it to get more or less evenly greased. When you have pinned down the vellum, rub it all over with this rag, particularly where text is to appear. Then rub the vellum well with pumice powder. Dust the pumice off very thoroughly with a clean rag and the surface will be found very pleasant to write or otherwise work upon.



16. PREPARING A QUILL PEN

We then come to the matter of ink and pens. For ink, an ordinary good black writing-ink will be found satisfactory for all practical purposes. It is really quite black enough; if it is good it does not fade; and it flows, of course, far more freely than Indian, or other specially-prepared inks.

Preparing Pens. The pens are a subject about which more must be said. In speaking of writing, it must be remembered that we are always referring to Gothic lettering. For ordinary small text a quill cannot be improved upon. The pen, when you buy it, is probably cut to an ordinary fine nib point. This must be altered thus: Lay the point of the pen down on the edge of a piece of glass; then, with a sharp knife, cut off the point, so that it will resemble that shown in the illustration [16]. This must be done in one cut, by placing the knife just above the point, and pressing it down with a slant towards the point. It must be remembered that this regulates the breadth of the nib, which must, therefore, be cut to suit the particular script.

Next grease the nib inside to about three-eighths of an inch from the point, either with the invaluable greasy rag or a brush, and feed the pen from another, applying the ink to the part above that greased. The ink will then only flow down the slit of the pen, and your writing will be clean and sharp. After much use, the point may want re-greasing. A quill, however, can only be cut to a point about one-sixteenth, or, at most, one-twelfth, of an inch in width. For larger writing a reed must be used. These can be cut to a much wider point. The treatment of the reed is the same as that of the quill, except that the application of the grease should be carried all over the nib, to prevent the ink soaking into the wood. Both the quill and the reed may want a little working on a piece of glass or the finger-nail before the ink will run to the point.

The Gilding Outfit. So much for our text. We will now consider the gilding. A slight outfit, if it can be called such, is necessary: (1) A gilder's pad, which is a piece of wood or card, with a wash-leather pad on the face of it; (2) a gilder's knife, which has a blade about 5 in. long and about ½ in. wide; (3) a small file to run along the edge of the knife, so as to give it the character of a very minute saw; (4) an agate burnisher—claw-shaped is the most useful; (5) an ivory, or bone, or agate tracer, which is a pointed piece of hard substance; (6) several small pieces of the thinnest and most shiny tracing-paper you can procure; (7) a small piece of vellum cut in the shape of a long triangle, to be used as a gilder's tip; (8) a small velvet pad, like a diminutive hat pad, for brushing off superfluous gold leaf; and (9) a book of unrouged double-fine gold-leaf. With regard to the size with which to apply the leaf to the

17. SPECIMEN OF MODERN ILLUMINATION
(By the Author)

vellum and at the same time raise it above the rest of the surface, a very satisfactory mixture for the purpose may be made by the following method: Grind some French clay to a fine powder, and add water until it is a stiff paste. Add French chalk in the proportion of about three of clay to one of chalk. Mix this well with a palette knife on a piece of glass. Now add drops of Le Page's liquid glue until the mixture is of the consistency of thin cream. Strain through a muslin of double thickness into a saucer to dry. When required for use, pour a few drops of water into the saucer, and stir gently with a brush, avoiding bubbles, until it is again of the consistency of thin cream. It can then be applied to the work with a brush. There are also many preparations made by the leading artists' colourmen which give satisfactory results.

After a while, the illuminator may prefer to experiment with parchment size, isinglass, red lead, gum arabic, honey, glycerin, borax, glair, or other ingredients, in making a size to his own particular liking. But nowadays, one has not generally time to worry about the making of materials, there being barely time to use them.

A Simple Method of Gilding. Having thus prepared your size, you will find the following the simplest method of gilding those parts of the design desired. The gold must be done first, before any colours are painted on, otherwise the leaf will be sure to stick to parts where it should not. First, then, paint over all the parts to be gilt thickly with the size, and leave it to dry, which will take about three to four hours. Be careful not to touch any part with the fingers, even after it is dry. Then take a gold-leaf from your book, by passing your knife carefully beneath it, and lay it flat upon the pad. It must then be cut approximately to the sizes you require.

To cut it, place the edge of the knife firmly upon the leaf and move it with a saw-like motion. Take your gold tip and moisten the edge of it by passing it along the tongue. Then touch the edge of the piece of leaf with the gold tip, to which it will stick firmly, thus enabling you to lift it and place it down where you wish.

Burnishing the Gold-leaf. Next, after covering up all but the particular bit of size you are gilding with the thin pieces of tracing-paper, breathe fairly hard (but exactly how hard must depend on experience) twice or three times upon the size, and lay the gold-leaf on it, being careful to keep the leaf as flat as possible. Place a piece of tracing-paper on it, and press down very hard with the finger, running the tracer round the edges, if necessary, to make it adhere firmly. Remove the tracing-paper and burnish the leaf very carefully. If the gold does not take the burnish at once, you have breathed too hard upon the size, thereby moistening it too much. Leave it a few seconds to dry slightly before burnishing. If the leaf comes off when rubbed with the burnisher you have not breathed hard enough, or you have touched the size with the finger; in that case, you must brush the leaf off with the velvet pad, breathe again, and apply another piece of leaf as before. If the burnish comes at once on the first trial, you are lucky. In that case, repeat this process till you have gilt all the parts of your design where raised gold is to appear. This method applies equally, of course, to any leaf other than gold.

If you wish to stamp the gold—that is, make a design upon it in depressed spots—this should be done as soon as possible after the leaf has

18. SPECIMEN OF ILLUMINATION FROM THE HARLEIAN MSS.

been laid on and burnished. Press the point of the tracer down firmly on to the gold, and it will leave the required depression. This practice of enriching still further the raised and burnished gold was very much in vogue all through the Edwardian period, and very magnificent is its effect.

Silver and Platinum Leaf. In mediæval work we frequently find attempts at treating silver in the same way as gold-leaf; but they appear never to have been satisfied with the result. This is not surprising when we remember that they had only silver-leaf to work with, which tarnishes into all the colours of the rainbow in a very short time. Nowadays, we have an excellent way out of that difficulty. Platinum leaf is made which will burnish almost to the brilliancy of silver, and will remain unchanged.

For illumination in colour ordinary moist water-colours are our medium, and an almost infinite variety of schemes present themselves to our choice. It would be useless to attempt a description. Nothing but a careful study of old MSS. will teach the student what colours are most pleasing, and how to contrast and arrange and alternate them. One may say that red, blue, and green are the key to them all. But this may be said of a picture. It is not a very useful or practical piece of information in either case. In most work of all ages, styles, and countries, the colours were not left plain, but their crudeness was toned down by a fine design in white line painted all over them. For this, do not use Chinese white, but enamel white. So much for our materials and how to use them.

19. ILLUMINATED PAGE FROM THE ARUNDEL PSALTER

Mediæval Practice. We must now add a few words on illumination as practised in England and France during the Middle Ages. In a word, the tendency through the ages was to lighten the design. Greek, Roman, and even early Gothic work was decidedly heavy, though perhaps rich. In France, the work was generally better than that done in England. It was early in the fifteenth century that the two countries utterly diverged in their development of illumination. In France, the design just prior to that date had consisted mainly of coloured leaves upon a coloured stalk. Dragons, grotesques, men, birds, etc., were freely introduced as well. But about the beginning of the fifteenth century the coloured leaves became nearly all gold, with coloured flowers and buds of almost infinite variety amongst them; the coloured stalk became a fine black line with fine little twigs from it. Nothing more beautiful or delicate than some of the best books executed at this period can be imagined. In England, on the other hand, the style became suddenly much more florid, the colours brighter, and the design, to say the least of it, more free; so free, in fact, as almost to merit the description of "careless."

The Purity of Mediæval Art. Our parting word of advice is that a student should remember that in mediæval days, when a new person stepped into this world, he found the arts, and illumination among them, in a very high state. From his birth he was accustomed to look upon a pure school of art, practically unadulterated by any outside influences. By the time, therefore, that he began to work and do his share, he had not only been through a careful study of all that had gone before, but he had a taste and quiet refinement in his nature which less fortunate mortals born in another age are oftentimes denied. For, with all our wonders and comforts and wisdom, our artistic efforts do undoubtedly lack the delicacy and refinement exhibited by the best work of the so-called Dark Ages. All this means, in a word, wade through numbers of the best MSS. you can find [18 and 19], copy from them copiously, and try to get the spirit of the work into yourself. Without this, technical knowledge is useless.

Continued

THE MANUFACTURE OF PAPER

The Paper-making Fibres and their Characteristics. Treatment of Rags in Paper-making. Wood Pulp. The Hollander. Paper-making Machinery

By CLAYTON BEADLE & HENRY P. STEVENS

SINCE the advent of civilised man paper—or something which has done service for it in bygone ages—has been a necessity. And the demand for paper and its application have, from its first introduction, increased with our methods of civilisation. From the materialistic point of view, it is the medium of all literature, and no civilisation could exist without it. The annual consumption per head of the population by different nations is regarded by many as a useful index of their civilisation and enlightenment.

Paper-making Materials. The materials used in paper-making and their sources are as follow:

FIBRES

1. *Flax*—Russia, Turkey, Italy, Egypt, France, Belgium, and Ireland.
2. *Hemp* (true)—Russia, Italy, Turkey, Hungary.
3. *Hemp* (best fibres, but not *Cannabis sativa*)—India.
4. *Hemp* (leaf fibres), *i.e.*, "manilla"—Philippine Islands, India, Ceylon, Mexico, Venezuela, West Indies.
5. *Hemp*, New Zealand hemp (*Phamium tenax*)—New Zealand.
6. *Cotton*—United States, Egypt, India.
7. *Jute*—India.
8. *Straw*—Holland, Germany, and other countries.
9. *Esparto*—Spain, Algeria, Tunis, Tripoli.
10. *Wood*—Scandinavia, Germany, Austria, Canada, United States.

MINERALS

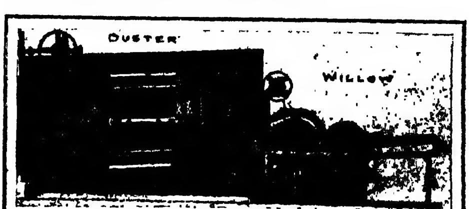
11. *China clay*—Cornwall, Devon.
12. *Agalite, asbestine, etc.*—Saxony, United States, Cornwall, South Africa.
13. *Pearl hardening*, terra alba, gypsum—England.
14. *Baryta*, barium sulphate—England, and other countries.
15. *Chalk*, whiting, carbonate of lime—Kent.

COLOURS

16. *Pigments* (ultramarine, etc.)—England, Germany.
17. *Coal-tar dyes*—England, Germany.

SIZING MATERIALS

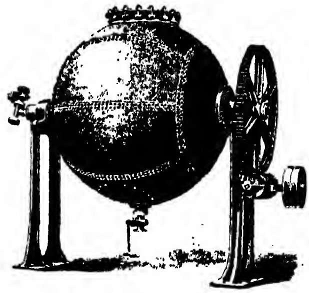
18. *Gelatine and glue*—England, Germany, France.
19. *Skins for ditto*—England, United States, Australia, South Africa.
20. *Resin*—America and France.



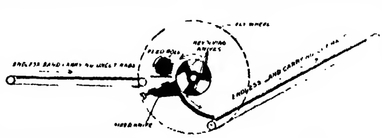
1. COMBINED WILLOWING AND DUSTING MACHINE

Paper from Rags. Cotton and linen rags may be taken together, as they are treated very much in the same way. The chief source of cotton and linen paper is derived from rags, new and old. The rags are imported into this country, and the supply is altogether inadequate to meet the present demands.

They are received, if imported from abroad, in bales weighing about 4 cwt.; if from merchants at home, in jute bags containing about 1 cwt. or 2 cwt. They are graded and sold according to quality, and are known under such names as "out-shots," "fines," etc. The trade name, however, cannot be taken as any criterion of value, as merchants' standards differ so much. The bales are "shot"—that is, opened and laid out on the floor—then fed into a "duster" [1], consisting of a cylinder about 20 ft. long by 6 ft. diameter, made to revolve slowly, and provided internally with prongs and covered externally with coarse wire netting. The axis of the duster is inclined at an angle, so that the rags travel from one end to the other while the drum revolves. The loosened dirt passes through the wire mesh. The duster is enclosed in a wooden box, and the dust which settles at the bottom is periodically removed.

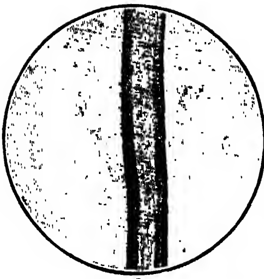


3. CIRCULAR RAG BOILER (Wm. Lord, Bury)



2. RAG-CUTTER WITH REVOLVING KNIVES

Cutting and Sorting Rags. The rags are then taken in baskets and cut up and sorted into different qualities. The "hurdle," or table on which the rag-cutters work, is covered at the top with a coarse wire gauze, and provided underneath with a shelf or drawer. As the rags are turned over on the table, the loose dirt falls through. Across the hurdle, sloping to and from the worker, and inclined at an angle, with the edge of the blade sloping towards the operator, is a broad, sharp knife. Handfuls of rags are taken by the operator, and cut up into short lengths of about 4 in. square by drawing across the knife. These are thrown into different bins according to quality. During this process, all buttons, whalebone, steel, and other harmful materials are thrown out as "mulch." All seams have to be opened, as they harbour dirt. In leading mills there are possibly twenty or thirty different qualities of rags. The general system of classification is to sort the linen from the cotton, each of which are in turn separated into different qualities from the best and cleanest to the dirtiest and weakest.



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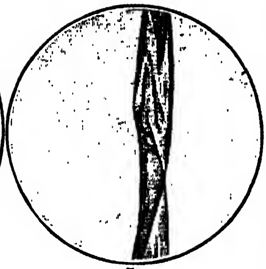

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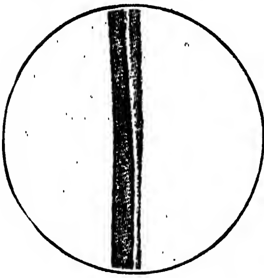

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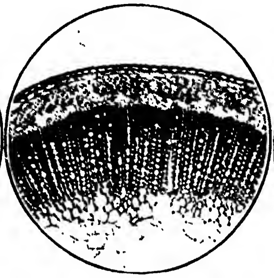

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Machine Cutting of Rags. Hand cutting is an expensive operation, and many of the mills now cut by machine [2], but the result is not so satisfactory for very high-class papers. Machine cutting gives rise to many chips, and the rags are not infrequently crushed and bruised, and the sorting and elimination of dirt is not so easy; but the machine has the great advantage of being cheaper, and at the same time fulfils all the requirements of many mills. The cut rags are now delivered into a " willow " [1], consisting of drums revolving at different speeds in a box, and provided with an iron prong, passing between fixed prongs. This beats the rags about and loosens the dirt, after which process the rags are delivered into a revolving duster like that previously described, where more dust and dirt is deposited; then the rags are discharged into a truck ready for the boilers.

Rag Boiling. The early boilers were simply open pans heated by direct fires. The present boiler is horizontal, cylindrical, or spherical [3]. The boiler is mounted on trunnions, through which the steam and water enter; it is made to revolve slowly, otherwise it is constructed very much like an ordinary steam boiler. It is provided with a manhole, and sometimes internally with iron spikes. The rags are now boiled under pressure with soap solution preferably in a spherical boiler [3].

Soda Liquor for Rag Boiling. The general method now is to employ caustic soda solution produced either by dissolving solid caustic soda with water in an iron tank, or by " causticising " soda ash solution by adding to it and boiling with it the necessary proportion of lime, whereby the carbonate of soda is converted into caustic soda, and the caustic lime to carbonate of lime, which latter forms a deposit or sludge at the bottom of the copper, whence the clear liquor is pumped. In a large, up-to-date mill, plant similar to that employed for causticising " recovered ash " from esparto liquors would often be made use of.

The soda required varies from 1 per cent. to 5 per cent., according to the quality of the rags, about half of which is, or should be, neutralised during the first hour, and nine-tenths at the third hour. Soda forms a soluble soap with the dirt, which is easily removed on washing, and softens the resistant lumps or *shive* in the linen.

The rags are next removed t the breaker, where they are broken in and washed. The washing is carried on for two or three hours, during which much dirt is removed.

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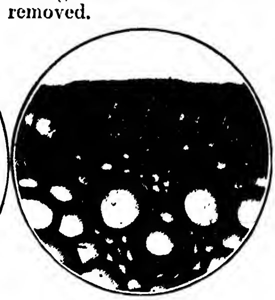

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PAPER FIBRES—HIGHLY MAGNIFIED

Esparto Grass. Rags failed altogether to supply the demand on account of the great increase in use of paper. This demand was met by the introduction of esparto grass by Routledge in 1862. The bale of esparto when received was formerly picked over carefully by hand as it passes along a travelling band; it is now dusted and delivered, without cutting, into a boiler of peculiar construction, known as a *vomiting boiler*. By an ingenious arrangement of pipes, the liquor which drains through the false bottom rises up the side tubes and vomits as a spray on to the surface of the grass, thus producing a constant circulation.

Spanish esparto gives the highest yield and best quality, and, consequently, commands the best price. For further details of esparto and rag treatment Beadle's "Chapters on Paper-making" and "Fibrous Constituents of Paper" may be consulted.

16. SECTION OF ESPARTO MAGNIFIED 52 DIAMETERS

The Removal of Liquors. In some systems, after the boiling is completed, the material, which is now reduced to pulp, is blown into another boiler under pressure, from which the liquor is removed by water displacement in such a manner that the liquor is diluted as little as possible. As in the case of straw, the liquor is passed on to the evaporators, where it is concentrated and reduced to "ash," and after causticising, is used over again.

Sizes of Fibres. In considering different papermaking fibres it is necessary first of all to form a mental picture of their relative sizes. This can be done by referring to the first two columns of the following table:

SIZES OF PAPER FIBRES

—	No. of fibres per inch lengthwise.	Fibres per inch placed side by side.	Beaten stuff. No. per inch.	Fibres cut during beating into about.
Cotton	1	1,200	30	30 pieces
Linen	1	1,200	30	30 pieces
Straw	75	1,250	75	Not cut
Esparto.. ..	18	2,200	25	About a third

Each of the fibres in question varies considerably in length and diameter, so that the average figures only are taken. Cotton and linen fibres are about an inch in length. Straw, which is very short, would require 75 placed lengthwise to equal an inch, and esparto about 18.

As to diameter, the cotton and linen are about equal, esparto being thinner.

The last column shows the length of the fibres as manipulated for the paper machine—that is, after they have gone through the processes of beating, to be described later.

Under magnification *cotton* often resembles a spiral collapsed tube, twisted on itself like a corkscrew [**4** to **6**].

Linen or flax [**7** to **9**] consists of transparent fibres, regular, smooth, and with tapering ends, and a very small hole or canal running along the centre. Sometimes it shows a slight marking, and here and there star-shaped puckerings. By the aid of these peculiar markings the linen fibre may, in some cases, be distinguished from hemp, to which it bears a very close resemblance, enough at times to baffle the skill of the most experienced. In its raw condition it contains waxy and "pectose" substances. The ash of raw flax varies from ·7 to 1·3, and of cotton in the raw state is about 1 per cent.

Esparto fibres [**15** and **16**] are generally smooth and regular, and when seen against cotton, linen, hemp, and wood, under a microscope, appear much smaller. They can be recognised generally in papers by the presence of little tooth-shaped particles [see **15** and **16**], which are the leaf hairs.

The straw fibre [**14**] somewhat resembles esparto both in size and appearance, but the serrated cells vary according to the kind of straw or its source. There is also present in straw a number of oval cells, derived from the pithy matters attached to the inside of the stem.

The wood fibre resembles none of the foregoing. That derived from Scandinavian wood shows long, wide fibres not unlike an elongated collapsed envelope with rounded ends. Chemical pine wood fibres [**19**] have characteristic pitted vessels on their surface like rows of small eyes. Poplar wood has characteristic vessels, with scale-like markings on the surface. The foregoing, as also hemp, jute, etc., are all, perhaps, better understood by a careful examination of the several drawings and photomicrographs.

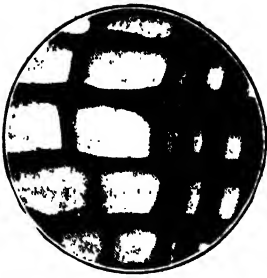
PAPER-MAKING FIBRES UNDER THE MICROSCOPE

No.	—	Magnification.
		Dia.
4	Cotton paper fibres, straight	300
5	,, ,, ,, twisted	300
6	,, ,, ,, curled	300
7	Flax stem, seen in section	30
8	Flax fibres contained in No. 7, greatly enlarged	325
9	Flax fibres as separated for paper-making (about)	70
10	Cotton and linen fibres in paper, reduced to fragments by beating	110
11	Fibres of paper containing wood (large fibre), esparto (small fibre)	90
12	Fibres of "Times" newspaper; wide fibres, wood; narrow, esparto; leaf hairs like teeth	90
13	Wheat straw, highly magnified, showing section of paper-making fibres (6-sided) with small holes in centres .. .	150
14	Bleached straw pulp ready for making paper, showing fibres and vessels ..	150
15	Bleached esparto pulp, not disintegrated, showing paper-making fibre; leaf hair and serrated vessels	325
16	Esparto leaf, showing whole section ..	52

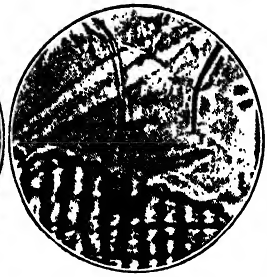
For large photomicrographs consult Beadle's "Fibrous Constituents of Paper."

17. UPRIGHT WOOD-PULP DIGESTER

Wood Pulp. In the process of conversion of wood into pulp, there are two great divisions, which can be expressed by two words, "mechanical" and "chemical." Mechanical pulp contains practically all the ingredients of the original wood, such as resins, gums, encrusting matter, etc., in addition to the fibre proper. The chemical pulp consists of the fibrous residue obtained by the removal of all foreign bodies by


18


19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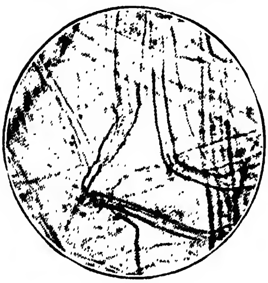

21


22


23

MAGNIFIED WOOD FIBRES

chemical treatment. Mechanical contains fragmentary particles, more or less fibrous, according to the nature of the wood and the care exercised in the process. Needless to say, chemical wood is much superior to mechanical in strength and lasting qualities. It is, of course, more expensive to produce.

Chemical Pulp. There are three processes for the manufacture of chemical pulp—namely, the "soda," the "sulphite," and the "sulphate" processes.

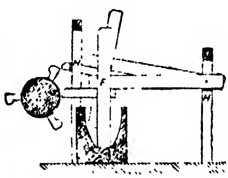
The soda process consists in "digesting" or boiling chips of wood under pressure in wrought-iron digesters or boilers, somewhat similar in construction to those described under Rag Boiling, the temperature ranging from 340° F. to 360° F., and the steam pressure from 100 lb. to 140 lb. per square in. The yield is decreased by increasing the amount of soda, and the soda used may be 15 per cent. to 25 per cent. on the weight of the wood, with sufficient water to saturate the mass. On the completion of the boiling, which takes about eight to ten hours, the digester is discharged, the strong liquors and washings carefully collected, concentrated, calcinated, lixiviated, causticised, and used over again, together with sufficient fresh soda to make up the loss on recovery.

MAGNIFIED WOOD PAPER-MAKING FIBRES

No.	——	Magnification.
		Dia.
18	Spruce wood, transverse section ..	325
19	Pine wood, longitudinal section ..	150
20	Mechanical wood pulp, ground from pine or spruce, showing large particles ..	150
21	Chemical wood pulp from poplar, showing characteristic puckered vessels ..	150
22	Chemical wood pulp from poplar; paper machine fibres only	150
23	Fibres of "Westminster Gazette"; paper consisting of chemical and mechanical wood	110

Yield of Pulp. Wood yields by chemical process approximately 50 per cent. of air dry pulp, more or less according to circumstances. The mode of cooking, etc., in the sulphate process is not unlike that of the soda: no special lining being required, this is greatly in its favour. The process has, however, the objection that quantities of sulphuretted hydrogen are generated. Works therefore need to be located where a nuisance may be tolerated.

Ten or fifteen years ago unbleached pulps lost 10 per cent. or 12 per cent. on bleaching. Now the cooking processes have been so much improved that the best brands lose on an average no more than 5 per cent. and consume approximately 10 per cent. of bleaching powder on the weight of the dry pulp. Some pulps bleach much more readily than others; hence we find pulps on the market advertised as "easy bleaching," which, however, on careful examination and compared with others, are often found to be misnamed.


24.
OLD WOODEN STAMPERS

The manufacture of wood pulp is a vast industry in itself, but inasmuch as England buys all (or nearly all) her supplies ready prepared, we shall content ourselves with a few general remarks on the subject.

A few photomicrographs of wood fibres are shown in **18** to **23**.

Primitive Beating. For the reduction of fibres to pulp, the first discoverers probably chewed the fibrous material and spat it out on a smooth surface to dry; after this some crude form of hand mill, resembling a pestle and mortar, was used. The same principle was in vogue, only on a larger scale, and driven by water power, up to about 150 years ago, but when wind and water took the place of hand power, the pestle was raised vertically by means of a cam on a shaft, and allowed to drop into a trough [**24**]. A battery of these stampers was constructed by gouging out the stem of a tree, so as to form a trough, the bottom of which was shod with iron, and nails with broad heads were fixed on the bottom of the stampers. Their general appearance would be like a batch of stampers for quartz crushing, only constructed in rather a primitive way from wood.

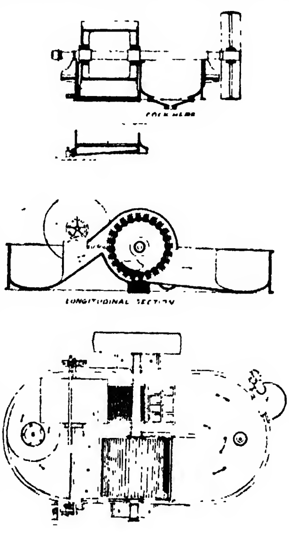
The Hollander. About the middle of the 17th century an instrument was invented in the Netherlands which yielded a hundred times as much as the stampers method, and did the work in about one tenth of the time. This instrument is known to this day as the "Hollander," and consists of a trough with semicircular ends, along the centre of which is a division known as the mid-feather. Across the trough is a shaft, bearing a heavy roll, having a diameter of about double the depth of the trough. The roll is provided with a number of knives placed a few inches apart, protruding an inch or two, and bevelled to form a knife edge. The roll is capable of being raised or lowered. The roll is brought down on to a "bed plate," provided with fixed knives placed at an angle. The trough is dished all round at the bottom to avoid sharp angles and to prevent lodgments of stuff. The centre of the bottom is practically all at one level except close to the roll, where it rises at a fairly steep gradient to the bed-plate whence it takes the curvature of the roll, to, say, halfway up, and suddenly slopes down the "backfall." The structure of the Hollander is the same in principle as it was in those early times, but, of course, with important structural improvements. The modern Hollander is larger and is constructed usually of metal instead of wood.

The Hollander at Work. The illustrations [25] of the modern Hollander in plan, in longitudinal section, and in cross section, are specially prepared to show how the machine is operated. The arrows show the travel of the stuff.

The plan shows on bottom near two ends the valve or plug to the left through which the beaten stuff is discharged to the chest; the valve to right for washing out when required; the valve at the top right hand of plan supplies wash water, which is drawn off by the revolving wire gauze covered washer drum by the scooping action of curved plates placed in side, as shown by dotted lines in the longitudinal section, the water discharging at centre, down the drain. The general contour of bottom and sides can be grasped by examining the above illustration. Just before stuff reaches the roll it is passed over a depression in the bottom covered with a perforated plate, where it deposits grit and heavy material such as broken buttons, etc. Sometimes there is an additional and larger false bottom placed at the opposite side of the mid-feather for a similar purpose. The former is shown in section. There are suitable mechanisms for raising and lowering the beater-roll and washing drums. The action of a Hollander beater-roll is two-fold.

Its first object is to separate individual fibres one from another, and, if necessary, to reduce their length to suit the requirements of the paper-maker. Its second object is to promote the circulation. For the latter purpose the bars are generally arranged in clumps, two or three together, with larger spaces in between the clumps. The front bar of each clump acts like a blade of a paddle-wheel, by pushing the stuff round and causing it to circulate. The time of circulation may be from two to five minutes, or even longer, depending upon the kind of stuff and its thickness—in fact, it varies enormously at different stages of the beating. When the beater is first filled with material, the circulation is very slow, but as the material gets reduced the speed increases. There is good reason for placing the bars of the bed-plate at a slight angle with those of the beater roll, as this tends to promote somewhat of a cutting action.

Figure **26** shows a modified form of the Hollander with two beating-rolls and washing drums. Modifications of Hollanders have been constructed in the form of a four-sided trough, each trough being provided with a beating-roll. The almost universal type, however, is the one we have described in detail.



25. HOLLANDER

From "Half-stuff" to "Beaten Stuff." The beating of rag half-stuff to finished stuff takes about four hours for writing-papers, about two hours for blottings, anywhere from six to twelve hours for "banks" and very strong papers where it is required that the stuff should work "wet." A breaker containing about 4 cwt. of rags, "dry weight," absorbs about 25-horse power, and takes four hours. The beater to the same quantity absorbs from 30 to 35-horse power. The power required is greater with strong and less with weak materials. In addition to the beating, the operation of refining is often resorted to. This is a continuous process, whereby the material is "cleared" of all knots and irregular particles.

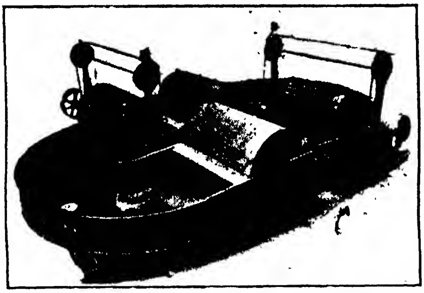
From Rags to "Half-stuff." The "breaking-in," as it is called, in the case of rags, jute, and hemp, is the first operation preparatory to beating proper. The boiled rags are discharged from truck into a "breaker," which is really a beater or Hollander, as above described, but with blunt bars. The roll is put down so as only just to clear the plate. This reduces the particles of rags to "half-stuff," or it performs the operation of unravelling the weaving. This takes about four hours. The breaker has a revolving washing drum covered with wire gauze, provided internally either with lifting buckets or syphons, by means of which it sucks the water through the meshes. A copious supply of clean water is added in front of the beater-roll, and dirty water is drawn away through the washing drum.

By this means a large amount of mechanical dirt is separated which cannot be removed so long as the rag is intact. The washing lasts about two hours, after which the operation is stopped and the "breaking-in" continued to the condition of "half-stuff." The breakers are usually situated on a higher level than the beaters into which they discharge.

An ordinary Hollander roll is provided with, say, 60 bars, and the bed-plate with 15, making, say, 900 contacts per revolution. The roll makes, say, 180 revolutions per minute, which gives us 162,000 "beats" or cuts. The bars are, say, 3 ft. 6 in. wide, so that we may compare a Hollander to a pair of blunt shears 3 ft. 6 in. wide, making 160,000 cuts every minute, through fine fibres. A "Taylor"

beater has a width of bars 60 in. and will make 1,000,000 beats in one minute. Hence, one reason for its greater rapidity of action.

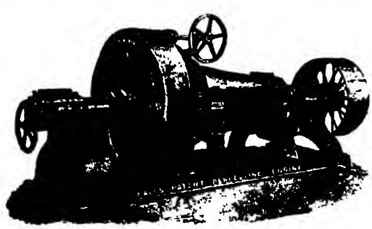
After the stuff leaves the beating engine (whether Hollander or other type) it generally passes to the "chest," or store tank, whence it passes on to the machine. It is now frequently the custom to leave the stuff from the beater in a somewhat unfinished state, and to pass it through a refiner before it reaches the machine. This type of machine is continuous in its action, the stuff passing in at one end and emerging in a finished, or "refined," condition at the other. One form of refiner consists essentially of a cone provided with bars carried on a spindle, and rotating at a rapid rate in a hollow cone provided internally with bars. The stuff in its passage between these bars is quickly refined. At the end of the cone is a rotating disc, revolving against a fixed disc, each provided with bars or knives. The well-known types somewhat on these lines are the Marshall [27], the Horne, and the Jordan, mostly, we believe, of American design. Another type is entirely on the disc principle, such as the Kingsland refiner, which has the advantage of occupying very little floor space.



26. HOLLANDER WITH TWO ROLLS

Hollanders, when first introduced, held perhaps only 50 lb. dry weight. Up to 25 years ago, they held only 3 cwt; 20 years ago, 4 cwt., with larger ones for "news." Now the largest hold 20 cwt. and over. With increased size there is increased economy, as proved by recent trials. Against this question of economy of power we must not forget that Hollanders above a certain size do not produce suitable material for all purposes. Thus, for hand-made papers, Hollanders holding $1\frac{1}{2}$ cwt. to 2 cwt. should not be exceeded, partly because the stuff is not so satisfactorily beaten, but more especially, perhaps, because the orders the makers have to fulfil are comparatively small. For fine machine-made rag papers, 4 cwt. is perhaps a convenient size.

Mechanical wood pulp, of which "news" contains about four-fifths, requires very little expenditure of energy—only a few horse-power hours per cwt—to reduce it to pulp for the paper machine. An enormous amount of power has been consumed in reducing it from pulp wood to sheets of dry or moist pulp, in the first instance, in the mills of Scandinavia and Canada, where it is prepared.



27. MARSHALL'S REFINING ENGINE (Bentley & Jackson)

The following table shows the power consumed in comparison with sulphite wood:

Manilla rope requires	87	per cent. more power than sulphite wood.
New jute threads require	110	,, ,, ,,
New twine ends require	273	,, ,, ,,
New linen threads require	331	,, ,, ,,
New rags require	409	,, ,, ,,

The "Umpherston" is a beater in which the roll promotes the agitation, as with the Hollander, but the stuff, instead of travelling round in a horizontal trough, passes underneath and up the other end, thus economising about half the floor space over the Hollander, a matter of considerable importance in some paper mills.

Why the Hollander is Sometimes Wasteful. Carefully conducted trials have demonstrated the fact that of the total power consumed by the Hollander when reducing air-dry sheets of sulphite to beaten stuff one-third is expended in agitating the stuff; and the fact has been demonstrated, after conducting numerous power trials, that there is in such cases at least 25 per cent. of the power wasted. This percentage is much greater with materials like esparto, straw, and mechanical wood than with chemical wood, but the figure would be less when dealing with rags and other strong materials which require a greater total expenditure of power in their reduction.

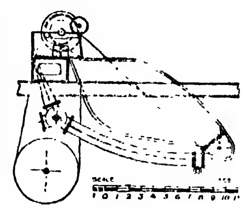
Modern Beaters. To save this useless expenditure of power, special beaters have been constructed whereby the "circulation" of the stuff is promoted by an independent agency. This circulation can now be done in patent beaters of the capacity of 700 lb. to 1,000 lb. dry weight at $2\frac{1}{2}$-horse power. The circulation in the Hollander of equal capacity might amount to from 10 to 15-horse power. There are several well-known makes of such beaters; among them may be mentioned the "Taylor" [28], the "Reed" [29], "Acme" and "Masson Tower." The stuff is either made to circulate round in a horizontal trough, as in the "Reed" and "Acme," or to travel downwards and up again, as with the "Taylor" and "Masson Tower": but in each case we have this all important factor—namely, independent circulation.

Only just sufficient material is made to overflow the bed-plate as the roll can operate upon, the roll remaining out of contact with the stuff, except where actual beating takes place. With the Hollander, the roll is immersed in the stuff up to about half its diameter, and the rapid beating and churning of the bars against the stuff uselessly absorbs an immense amount of power. With the patent beaters, the bars of the roll are placed equidistant from one another, and close; this is a very great advantage. In fact, the "bars" of the roll and "bed-plate" are located and constructed so as to beat to the best advantage, hence the economy. This course cannot be adopted with the Hollander, where the bars have to promote the circulation as well as do the beating.

When treating very strong material, such as linen rags, the percentage of power wasted is comparatively small, hence the advantages of a patent beater are less obvious than with materials like esparto, mixtures of chemical and mechanical wood, straw, etc., and there are reasons in favour of the Hollander which cannot be discussed here. In certain cases, moreover, the agitation is not uselessly

expended, as it improves the character of the stuff. And, moreover, very large Hollanders, such as those of a capacity of 20 cwt., have been proved by recent trials to be far more economical in proportion to their output than smaller ones, so that the last word has not yet been said on this subject: but in the aggregate, for the majority of papers of modern modes of manufacture, results tend in favour of that kind of beater in which the circulation is promoted by an independent agency.

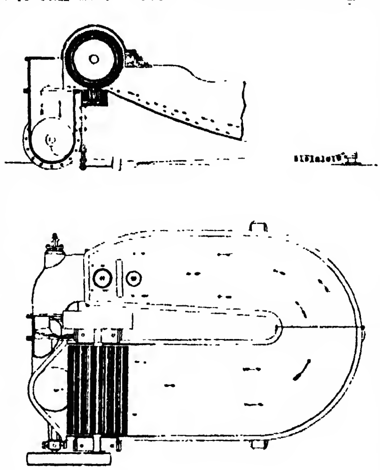
Bleaching Rag Half-stuff. The bleaching of rag half-stuff is ordinarily done by adding bleach solution to the "potcher," which resembles **25**. The bleach required varies, according to the quality of rag, from 1 per cent. to 5 per cent. This is emptied into "steeping" tanks made of brick or concrete, surrounded with cement and paved with perforated earthenware tiles. When the bleach has exhausted itself after 18 to 24 hours, the waste liquor is drained away and the bleached half-stuff dug out and lifted to the beaters.



28. TAYLOR'S BEATER

Another way is to add the bleaching liquor to the beater, the bleaching being effected while the disintegration of the fibre is being proceeded with. In this latter case, the work of bleaching has to be done in two or three hours, which necessitates the addition of a larger proportion of bleaching solution, only about half of which is actually used up, the other half having to be neutralised by the addition of sodium sulphite or sodium thio-sulphate, as antichlor. This process costs more for chemicals than the "steep" bleaching, but does not interrupt the operation, and saves time. But it can be resorted to only for the finer qualities of rags which require comparatively little chemical treatment.

Bleaching Chemical Wood. Unbleached chemical wood pulp that requires to be bleached is ordinarily added to a "potcher," when the fibre is sufficiently separated: a 6° Tw. (= 5 per cent.) bleaching liquor is added (equal to from 10 per cent. to 12 per cent. of dry bleaching powder) on the dry weight of the wood pulp. When properly mixed, the mass is discharged into steeping tanks, left for 24 hours, drained, and lifted to the beaters.



29. REED'S BEATER
(James Milne & Son, Ltd.)

Older Methods of Bleaching. The ordinary method of bleaching by adding the bleaching solution to the potcher, and emptying same to the steeping tank, involves considerable handling and labour, and usually takes 24 hours to accomplish. Moreover, after the steep-bleach is exhausted the half-stuff has to be raised again to the level of the beaters. Something better is wanted to save time and money. In paper-making, as in other industries, the modern tendency is to centralise everything, such as power, plant, etc. With such centralisation comes economy of power, saving of labour, and increase of output. Such points as these are of paramount importance to the English paper-maker, who is compelled to economise in all directions to fight foreign or neighbourly competition. The avoidance of handling results not only in the saving of power, etc., but prevents also contact with dirt, which is difficult to avoid under ordinary circumstances, even when great care is exercised.

Now, it is possible to avoid the handling of the stuff altogether from the time it enters the "breaker" until it reaches the "reel" of the paper-machine as finished paper. By operating valves, wheels, levers, etc., the stuff can be made to pass through the various mechanical and chemical operations out of contact with all disturbing influences. In order to show how this is done, we shall describe the most recent and up-to-date plant by means of which this is now so successfully accomplished. Figure **30** shows the arrangement of the plant recently erected. In this particular installation, in another building the stuff is bleached in the manner to be described later, and conveyed in diluted form through 90 ft. of copper piping to the final bleaching tower, C. This is known as a Masson Tower, and is provided with a slowly revolving gauze-covered drum, B, driven by a gear wheel, A. The drum, in this case, acts as a washer by removing or washing out the residuum of bleach after the bleaching operation is accomplished. During the operation of bleaching, and its removal by washing, the stuff circulates round and round in the tower in the direction of the arrows, being propelled by the circulator G. When the bleaching is completed the washer B draws out the residuum of chemicals. By turning a valve the circulator discharges the contents through a copper pipe into one or other of the four Masson tower beaters, marked E. These tower beaters each in turn reduce the stuff to the condition required by the paper machine, and deliver same to the stuff chests. The circulator G is driven by a motor, H. The beating, circulating, and discharging of stuff in the Masson towers is motor-driven through the shaft K.

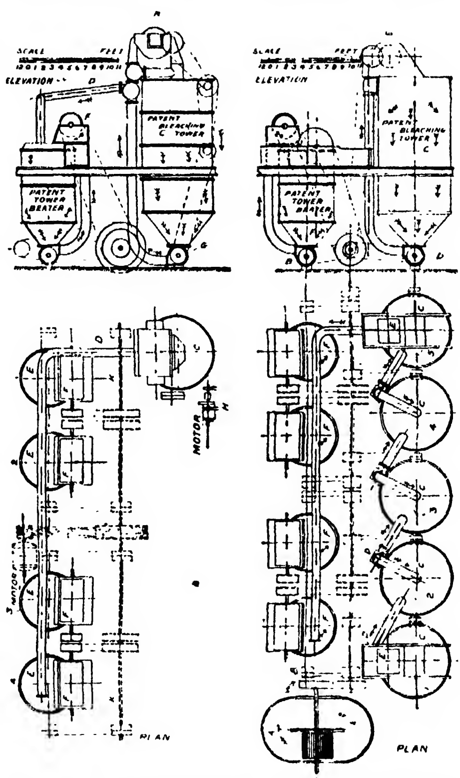
The travel of the stuff in the Masson tower beaters (E, Nos. 1 to 4) is promoted by the circulators underneath, and passes round and round in the direction of the arrows in a similar manner to that of the Masson bleaching towers. The roll F at the top does the beating. In the centre, and close to the top of each of the bleaching towers and beaters, is suspended a cone-shaped hood, which nearly fills the tower, but leaves a small space for the stuff to pass. On the point of this cone the stuff is made to flow and slide down in all directions, then passing through the narrow ring-shaped aperture, between the edge of cone and tower. By the aid of this ingenious contrivance, the stuff is thoroughly and uniformly mixed, and an absolute distribution insured, such as is not possible under ordinary circumstances with the Hollander.

Continuous Bleaching. The section on right in **30** shows how the cycle of operations can be performed in a comparatively small space under one roof, so that the man in charge has everything

at his elbow. We have here four of the Masson tower beaters F and five bleaching towers C. The stuff, consisting either of unbleached sulphite pulp or esparto, is first put into the large breaking engine A, where, if necessary, it is washed by a washing drum (not shown). Attached to this engine is a patent circulator (not shown) which empties the breaker and discharges the stuff into the No. 1 tower C. While No. 1 tower is being filled to the brim by repeated charges, the washer drum E (usually called the *circulator*) is put into operation, by which means the water is drawn out, reducing each charge of stuff to about half its former value. When the tower is full it is finally reduced by concentration so as to pull down the level a foot from the top, to make room for the bleaching liquor. Each tower absorbs 30-horse power when circulating. The passage from one to the other takes from 6 minutes to 10 minutes. The stuff rests still in towers 2, 3, and 4, for about 2½ hours; therefore, out of a total of 150 minutes in each, the circulation is promoted for, say, only 10 minutes, or $\frac{1}{15}$th of the time. If going continuously, each tower would be absorbing 30-horse power, but as each circulates for only $\frac{1}{15}$th of the time, it is absorbing on an average only 2-horse power. This applies to the three inside towers. As the two outside towers have to do the concentration and washing respectively, the circulation in each has to be in operation 30 minutes out of 150 minutes, or $\frac{1}{5}$th of the time, which is equal to an average of 6-horse power.

The Advantages of Concentrated Stuff. The tower beaters each hold stuff sufficient to produce 14 cwt. of paper. The bleaching towers, measuring 16 ft. high by 8 ft. 6 in. internal diameter, each hold concentrated stuff sufficient for upwards of two tons of paper. Their capacity in cubic feet is about 950. The five towers, therefore, together hold 10 tons (paper), and under ordinary conditions of making, the stuff passes through them at the rate of 60 tons of paper per week. The unbleached stuff emerges as a bleached product in about 13 hours to 16 hours, being about half that required in the ordinary "steep" bleach. The ordinary concentration in the Hollander or potcher is 3 per cent. to 5 per cent. of dry fibre, according to circumstances. In these towers the concentration is approximately doubled. The rate of bleaching largely depends upon the concentration, because, if we get the bleach into a smaller volume, it will be chemically more active, and will do its work more quickly in consequence. Thus it is by a system of this kind, which is quite a revolution over the time-honoured methods so long in vogue, that economies in time, labour, power, and chemicals can be effected. If such a concentration were produced in the ordinary potcher, the stuff would be too thick to travel round, and would, therefore, be entirely unworkable.

Note that right hand plan of **30** is a complete installation all under one building, such as would be installed in laying out a new mill. The "washer" is the same in construction as the "concentrator." It consists of a revolving drum covered with wire gauze, similar to the drum of an ordinary breaker, as in **25**, but capable of discharging the wash water at each end. The stuff is pumped up to it by the circulator. The concentrated stuff is paddled forward by triangular projections fixed to the outside of drum, the drum revolving in a kind of trough somewhat like the "back fall" of a beating engine.



30. THE MASSON TOWER BLEACHING SYSTEM

The Continuous Passage of Stuff. But to return to our description **30.** No. 1 tower is emptied in about six minutes by the attached circulator, D, into No. 2 tower C, where it rests undisturbed for about 2½ hours; the circulator in No. 2 tower C in about six minutes empties the stuff into No. 3, where it again rests; from No. 3 to No. 4, and then into No. 5 tower. Immediately the bleach has done its work the residuum of chemicals is quickly removed by means of the attached wash drum E. The bleached and washed stuff in No. 5 is now discharged from one or other of the four Masson tower beaters opposite. The process of bleaching is practically continuous, as immediately No. 1 tower is empty it is refilled by repeatedly filling and emptying the breaker, and passed on to No. 2, No. 2 to No. 3, etc., so that the one end, No. 5, is constantly being discharged into one or other of the four tower beaters F, which each in turn do their work and discharge the finished stuff into the stuff chests ready for the paper-machine.

This installation can easily be looked after by one beaterman, and one man in charge of the bleaching towers and breaking engine. In addition to the plan, we have shown in each case the elevation, so as to render the general arrangement more intelligible to our readers.

The above arrangement is after the manner of plant designed and installed by Messrs. Masson & Scott, Ltd., of Fulham.

Continued

THE NURSE AT WORK

Preparation of Poultices, Fomentations, and Medical Baths. Necessary Precautions in Infectious Cases. The Nursing of Sick Children

By Mrs ROBERT E. NOBLE

Fomentations. Fomentations are exceedingly useful remedies, their effects being the same as that of poultices. They have the advantage of being more quickly prepared than the latter, and are quite light, as they rest on the diseased part. To prepare a fomentation satisfactorily everything necessary should be placed at hand ready for use before the process actually begins. A kettle of water should be on the fire and a large bowl put to get warm in readiness. A short roller towel is laid across the bowl with two boiler sticks (children's hoop sticks will do well) in the loops of the roller. Between the two folds of the towel is placed the piece of soft flannel which is to be used for the fomentation. The boiling water is then poured into the bowl over the roller towel and allowed to saturate that and the flannel. Two people should twist the sticks in opposite directions, at first keeping the flannel below the level of the water, and only giving the final twists above that level. Next the flannel should be taken out, shaken up, and gently applied to the diseased part. It is covered with macintosh, and then by two or three folds of cotton-wool or flannel. Turpentine stupes are ordered for severe intestinal pains and cramp. The flannel is sprinkled with about a tablespoonful of turpentine, and the fomentation prepared as described above. Fomentations need to be replaced about every fifteen minutes, and when the treatment is concluded it is important that the parts that have been against the heat should not be chilled. A thick layer of cotton-wool covered by flannel will minimise this risk.

Poultices. Poultices are less frequently used now than they were in the past. Fomentations to a large extent take their place, but for certain purposes the poultice is still without a rival. For cleansing wounds and hastening the discharge of matter from an ulcer, the poultice is beyond doubt invaluable. In every case the poultice should be made of the most suitable size—not too large to inconvenience the patient, nor too small to perform its proper functions.

The Linseed Poultice. A rather large knife with a flexible blade or a spatula is put to get hot in a jug of hot water. A basin is rinsed with hot water to warm it, and then about a third of a pint of water is placed in it—more or less as required, according to the size of the poultice to be made. The linseed is then sprinkled in with the left hand, the right hand stirring with the spatula. The linseed is added till no more sinks into the mixture. Then, after a final stir, the ingredients are spread evenly on a piece of soft linen previously placed on a hot plate. The linseed and water should come away cleanly from the side of the basin, and it will be found that the spatula spreads more smoothly if it is occasionally dipped into some very hot water. The mixture should be spread smoothly over the cloth and may be left to come directly into contact with the patient or else covered with a fine piece of muslin. This latter method is not so good. A little vaseline may be smeared over the surface of the mixture, and the edges of the cloth neatly turned in about half an inch. The consistency of the poultice should be neither dry nor too liquid. If it is too dry it is not so beneficial to the patient; if too liquid it is decidedly detrimental to his comfort.

The linseed used should be carefully chosen. The ordinary *linseed meal* of the chemist is of little value, since it is merely ground oil-cake, from which all the value has been pressed. *Crushed* linseed, on the other hand, contains the natural oil, which has a great medicinal value.

Mustard and Linseed Poultice. Two tablespoonfuls of mustard are mixed to a smooth paste with hot, not boiling, water. Then boiling water is added and the linseed sprinkled in as before. Some people prefer to mix the mustard and linseed dry, but this is quite optional. A mustard poultice makes the skin of the part to which it is applied very tender. Vaseline is a soothing application, and the inflamed skin should be protected from cold by means of cotton-wool. Should a succession of poultices be used, as is nearly always necessary, the new one should be ready immediately to replace the one that is taken off.

Charcoal, Bread, and Starch Poultices. Charcoal may be incorporated with the linseed and part also sprinkled on the surface of the poultice. About $\frac{1}{4}$ to $\frac{1}{2}$ oz. of best wood charcoal is used. Such a poultice is generally used for unhealthy wounds and sores.

A bread poultice is very quickly and easily made. A basin is scalded and some boiling water placed in it. To this is added some breadcrumbs. The mixture is put to stand in a warm place, such as the hearth, for about five minutes. Then the unabsorbed moisture is drained off and the bread spread on linen. If the poultice is intended to soothe, it will be more effectual if made with milk.

Starch poultices are made by first mixing the starch (ordinary laundry starch is used) with cold water, stirring it to form a smooth paste. Then boiling water is added till the right consistency is arrived at, and the starch is spread in the ordinary way. Starch poultices are non-irritant in their action, and as soothing applications they are very useful.

Mustard Plasters. Mustard plasters are quite easily made by spreading ordinary table mustard in a thin layer on brown paper and covering it with tissue paper. The plaster must not be left on the skin very long as its effect is very irritating, and may produce blisters unless great care is exercised.

Medicated Baths. For various diseases different medicated baths are ordered. The preparation of such a bath is entrusted to the nurse, who should make careful note of the doctor's directions. In certain skin diseases and rheumatism soda and sulphur baths are sometimes ordered. In a soda bath two or three pounds of washing soda may be dissolved in the water; if bicarbonate is used a quarter of a pound will suffice. In a sulphur bath the amount used will depend on the doctor's orders, about 4 oz. of sulphate of potassium going to 30 gallons of water. Various kinds of salt baths

are ordered in some cases of rheumatism. Sea water is excellent for this purpose, but if not obtainable, the sea-salt can be dissolved in hot water, and this preparation has great value.

Oatmeal baths are soothing to patients suffering from skin complaints. A bag containing from half a pound to a pound is squeezed in and out of the water till the water feels soft to the hand. The same bag can be used to soften the water of two or three baths. A mustard bath, whether used as a foot bath or for total immersion, is often useful. For a cold in the head few remedies are more efficacious, and a child suffering from croup will be best treated with such a bath.

How to Administer a Cold Bath. A cold bath is sometimes ordered to reduce the temperature of a feverish patient. The patient suffering from hyperpyrexia (high fever) is so ill that if the doctor orders a cold bath he will probably be present to look after its administration. A tepid bath with water at a temperature of about 90° F. is prepared and the patient placed in it. Then the temperature of the water is allowed to fall to about 60° or 65° by the addition of ice-cold water and pieces of ice. The feverish patient's body will give out enough heat to raise the temperature of the water for some time, but in a few minutes he must be put back to bed again. He should be covered only with the sheet and perhaps a blanket over his feet. For some time his temperature will continue to fall.

The Hot Bath. When a hot bath is ordered, the patient is wrapped in a blanket and put into a bath at a temperature of 100° F. to 110° F. The temperature is kept constant by the addition of successive portions of boiling water, which should be poured cautiously down the sides of the bath. The bath should be covered over with a blanket to prevent loss of heat. Meanwhile the bed should be prepared with a large macintosh covering the lower sheet. Then, after the patient has been in the water about twenty minutes, he should be lifted out, blanket and all, on to the macintosh and rubbed down with a warm towel. A warm flannel shirt is slipped on, and he is wrapped in the warm, dry blanket; the macintosh is removed, and he is quickly covered up in bed. Such a bath is given sometimes to induce free perspiration. In that case hot drinks should follow, and hot bottles may be put in the bed. The uses of a hot bath are many. It may be intended to diminish pain, to relieve delirium, and to allay convulsions in a young child.

Vapour Baths. In administering a vapour bath, the patient should be enveloped in a blanket, and seated on a wooden chair standing in a foot-bath. The blanket should fall over the sides of the bath, leaving the patient's head free, but all other parts of his body exposed to the vapour from the hot water. His feet should rest on a fold of blanket on the side of the bath. Then the bath should be half-filled with boiling water. When the steam seems to be exhausted, hot bricks and fine clay balls can be dropped into the water to generate more steam. The patient should be exposed to this vapour for about twenty minutes. He should then be rubbed down quickly with hot towels, dressed in a flannel shirt, rolled in a blanket, and put into bed. A vapour bath is used for cases of rheumatism, gout, etc. The greatest care must be taken to avoid chills after these hot baths, or serious complications may arise.

To give a vapour bath in bed, the patient, enveloped in a blanket, lies under a bed-cradle, which supports the bedclothes. Over this framework rests a macintosh, and three or four blankets. Under the patient is another large macintosh covered by a blanket. The blanket which enveloped the patient is then drawn out, and the spout of a bronchitis kettle inserted between the blankets. The kettle should be resting on a properly-protected stove, and the steam will pass freely into the bed and act on the patient's skin. Great care must be taken not to scald the patient and not to burn the bedding or upset the stove. In about twenty minutes the kettle is withdrawn, the cradle removed, also the macintoshes, and the patient remains in blankets, carefully protected from all chance of catching cold.

Hot-air Baths and Hot Packs. The preparations for a hot-air bath are the same as for a vapour bath, and the patient is enveloped in a blanket. Hot air is then passed in from a specially-constructed lamp. The greatest care must be taken to avoid an accident. The lamp must be well guarded, and every care taken that the patient is not burnt. Hot-air baths are ordered for patients suffering from Bright's disease, and such a patient may be in a semi-conscious or unconscious condition. Such a patient might have his skin seriously burned by any carelessness on the part of the nurse, and such burns heal with difficulty.

A hot pack is used to induce perspiration much as a hot bath is used. It is easier for the home-nurse to manage alone, and, if skilfully given, is very efficacious. The patient's nightshirt is removed, and he is placed in bed on a hot blanket, under which is a macintosh. A sheet or blanket is rolled up lengthways, dipped in boiling water, and wrung out much as a fomentation would be, using a draw-sheet or very large towels as wringers. The patient is rolled on to his side in the bed, and the hot sheet and blanket laid beside him still only half unrolled. He is turned over to rest on this, and then the rest of the sheet is unrolled, and he is enveloped entirely in it with the blanket on top. He is then covered with another macintosh and additional blankets. Then he may be given plenty of hot drinks and hot-water bottles may be placed in the bed. This treatment should induce copious perspiration. In about twenty minutes the wet sheet, blankets, and macintosh may be withdrawn, and their place taken by a hot, dry blanket.

The same precautions against a chill must be taken as after a vapour bath. Generally the patient will be very drowsy after the pack. The best time to administer it, therefore, is in the evening, so that he may settle down to sleep undisturbed for hours.

Cold Packs. A cold pack is used to reduce the temperature. The only difference in administering a cold pack is that, instead of using a hot blanket, a sheet wrung out in cold water is used, and instead of heaping blankets on the bed, a single sheet is used as a covering. Sometimes pieces of ice are rubbed over the patient's skin. Every precaution must be taken in case faintness should attack him.

Ice is exceedingly useful in the sick-room. Some should be broken up and placed in readiness in a small dish. A thirsty patient will find small pieces very comforting to suck. Ice applied to a wound that is bleeding freely may staunch the blood flow. An ice-bag is prepared by filling a bag with pieces of ice, and suspending it over the patient by means of a bed-cradle. The entire weight of the bag should not rest on the patient; part of it only should rest against the head or limb, as ordered. The ice must be renewed from time to time as it soon melts.

Sometimes the ice is placed in pails—small ones, such as children use at the seaside—which are

suspended from a cradle over the patient. The cradle is covered with a sheet and left open at each end, so that a stream of ice-cold air passes over the patient. The patient should be dressed in a flannel nightshirt, and his feet placed against a hot-water bottle.

Cold-sponging. Cold-sponging is another means by which the temperature is reduced. The patient's whole body is sponged over with water at the ordered temperature. The face, neck, arms and chest should be sponged first; then the abdomen and legs, and, lastly, the patient's back. The sponging should be steady and very gentle. Then the patient should be dried, placed in a dry nightshirt, and left in bed covered with a sheet only, or perhaps one blanket. Throughout the process his feet should be kept warm, and he should be protected from draughts.

Inhalations. Inhalations of ammonia or of oil of eucalyptus, or of some terebene preparation is sometimes ordered. A teaspoonful of the particular medicament is placed in a wide-mouthed jug, a pint or more of boiling water is poured over it, and the patient inhales the vapour which rises. He holds his face over the mouth of the jug, and waste of vapour is prevented by holding a towel round the face.

The drugs used for the treatment of bronchitis are carbonate of ammonia, ipecacuanha, squills, and assafœtida.

Nursing Infectious Diseases. In infectious cases, the room chosen should be near the top of the house, and, if possible, no person beside the nurse should use the rooms near that of the patient. All unnecessary furniture must be taken from the sick-room, and all carpets and upholstered furniture and thick curtains banished. Such articles become impregnated with the source of infection, and can only be disinfected with the greatest difficulty. Light, washing curtains may be used, and the floor covered with Indian matting. The woodwork should be wiped over with a cloth dipped in some diluted disinfectant.

Over the patient's door a large sheet should be hung, wrung out in a solution of some disinfectant. One corner of the sheet should dip into a bowl of the same disinfectant to make good by capillary attraction the liquid lost by evaporation. The value of this precaution is often disputed, but it does probably filter the air which escapes from the sick-room, and so protect the other members of the family, and it certainly acts as a danger signal in the shape of a warning.

The Nurse's Health in Infectious Diseases. When nursing an infectious case, the nurse should pay scrupulous attention to necessary precautions and minimise her own risk of taking the disease, and that of other members of the family. She should not enter the sick-room until she has taken food, as she is more susceptible to infection when her stomach is empty. Should she cut herself accidentally, and notice any little wound or sore, she should cover it at once with adhesive plaster or a bandage. She should wash her mouth frequently with a suitable disinfectant, and try to avoid swallowing her own saliva. She should not lean over her patient more than it is absolutely necessary in nursing the disease. Every day she should take exercise in the open air, carefully changing her infected clothes for the purpose.

She should sleep for seven hours consecutively in every twenty-four, and this sleep must on no account be taken in the sick-room. The nurse must not take her meals in the sick-room, and any food that is discarded by the patient should be at once burned, as it would be a dangerous source of infection if eaten by others.

How to Nurse Sick Children. Children must always be watched carefully, because they cannot accurately describe a pain; and, in a child, a disease runs its course so rapidly that it becomes very important to detect its earliest stages. A child's body is more delicate than that of an adult, and disease quickly obtains a firm hold.

If the child seems cross and out of sorts, inclined to be fretful and peevish, in all probability there is something wrong with its health. These small beginnings of illness must be carefully noted and checked, if possible, as they may give rise to serious and dangerous results.

Points to Observe. The child who is sickening for a disease has often a capricious appetite, and its sleep is generally disturbed. Its position in bed should be carefully noted, as a premonitory warning of the presence of disease is given by unusual position. For example, lying with knees drawn up is a sure sign of abdominal trouble. The child instinctively knows that by drawing up its knees the pain is diminished, for the pressure on the abdominal organs is relieved by relaxation of the muscles. Again, earache or an incipient abscess may be indicated by the child pressing its head tightly to the pillow.

A dark shadow under the eyes and emaciation of the body are also unfavourable symptoms; the layer of subcutaneous adipose tissue which gives the rounded appearance to the limbs of a healthy child is quickly absorbed in the early stages of a disease: the child's skin becomes loose, wrinkled, and the muscles flabby.

Even a healthy child should not be allowed to sleep with its head under the bedclothes. The air in the bed is vitiated, and laden with particles from the skin and breath, and with carbon dioxide from the lungs. Moreover, this curled-up posture is very bad for the child's figure, and will undoubtedly result in round shoulders, and even curvature of the spine.

Much patience is needed in nursing a sick child. Its whims must only be gratified judiciously, and nothing is so bad as the method by which obedience is only obtained as the result of bribes. The conduct of the child when it is ill will differ but slightly from its normal behaviour when well. If it has been taught that obedience is necessary on all occasions, the chief difficulty in nursing will be obviated.

Nursing a Nervous Child. An excitable and nervous child must be treated with special care. A sudden fright or shock may result in complications of the disease. Many childish complaints are treated with a preliminary warm bath, but the hot steam arising from it is alarming to the little patient. In such a case, it is a good plan to spread an old blanket over the bath and lower the child on it into the water. The hot-water tap should never be allowed to run whilst the child is in the bath; many fatal accidents have resulted from the neglect of this simple precaution. The nurse should carefully ascertain that the water is at the required temperature by testing it beforehand with the thermometer. The hand is an unsafe guide; it is better to use the elbow if a thermometer cannot be procured. During the bath the attention of a nervous child can be distracted by some floating toy, a paper boat, or even a feather, or an imaginative nurse can delight her small patient with a fairy tale if her mind is not already overtaxed by her responsibility.

NURSING *concluded; followed by* SCHOLASTIC PROFESSIONS

ENGRAVING IN MEZZOTINT & WOOD

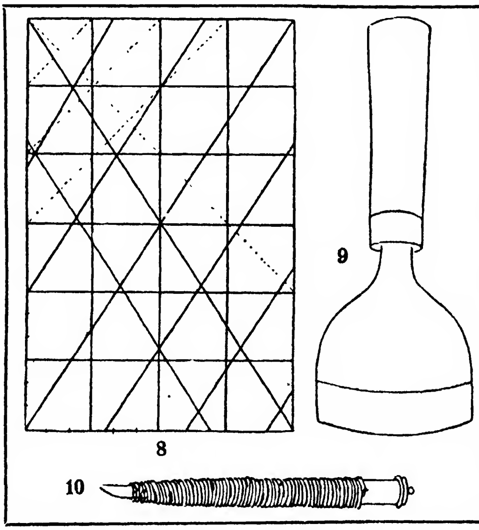
ENGRAVING continued from page 6111

The Most Popular Engraving Method. Mixed Mezzotint. Facing Copper-plates with Steel. The Schools of Wood-cutting and Wood-engraving

By EDWARD F. STRANGE

Of all the varying methods of engraving a metal plate, none is receiving more popular attention nowadays than the peculiarly British art of mezzotint—that is, so far as the productions of bygone engravers are concerned. The number of modern practitioners of the method is, however, small, and although some among them are no whit inferior in skill or taste to their predecessors, the vagaries of fashion are such that they receive but a paltry measure of support from their contemporaries. Their consolation is that they are undoubtedly working for the benefit of future generations.

This manner of engraving differs essentially from all others in that its practice entails the use neither of point of any kind nor of acid. The first essential is the laying of a ground; but this is, in itself, an integral portion of the actual graving to be done. Again, as with an aquatint, the need is to provide the whole surface of the plate with the means of retaining ink: but in this case it is done by roughening the plate with a tool. This is termed *rocking*. The tool used is of steel, somewhat resembling a broad chisel, but with its cutting edge shaped to the segment of a circle [9]. The outward face of this tool is regularly grooved to the extent, as a rule, of from 40 to 80 grooves to an inch. The curve is ground, from within, to an edge, which produces a point corresponding to each of the ridges between the grooves. It may be mounted with a short perpendicular handle, and so used, but for the preliminary laying of the ground, is better affixed at a right angle to a rocking pole, the opposite end of which is provided with a free slot travelling horizontally between guides fixed to a table.



MEZZOTINT ENGRAVING
8. "Ways" of rocking a mezzotint plat 9. Rocking T 10. Scraper

Rocking and Graving the Plate. The pole should be some 4 ft. long. The plate is held with one hand, while the tool is steadily and regularly rocked with the other, the motion causing it to pass in a straight line from one edge of the plate to the other, making a series of indentations as it goes, and at the same time ploughing up the copper to form a burr. In order to make sure that this roughening is equally distributed, the plate should first be marked out with guide lines for the rocker to follow, and these lines, termed *ways* [8], are arranged at various intervals and angles, by means of a scale. About 40 ways give a good ground, and continual re-sharpening of the tool is necessary during the operation. If the plate were now charged with ink and printed, the result would be a rich, velvety black of the finest quality attainable by any process of engraving.

The picture is produced by scraping away this ground with a broad-bladed double-edged scraper, terminating in a point [10]. It becomes necessary, however, at this stage, to bear well in mind what has been done to the plate. Highly magnified, the copper would present, in section, a series not only of elevations, but of depressions. The mere cutting away of the burr to the original level of the plate would produce, when printed, only a middle tint, as compared with the full depth of blackness given by the undisturbed ground. To obtain the highest lights, the hollows must also be cleared out, otherwise they would hold a considerable quantity of ink and print effectively. Between these two extremes of untouched burr and cleaned out indentations lie the possibilities of obtaining every shade and delicacy of tone in the whole gamut of monochrome.

The Charm of the Mezzotint. It will have been gathered from this description that line does not exist in pure mezzotint. Herein is one of the great difficulties of the art—that of obtaining adequate definition of form. At the same time, the universal softness necessitated by the process constitutes perhaps one of its most alluring charms.

It is usual in practice to transfer the outlines of the picture to be engraved by means of gelatine after the ground is laid. The work then proceeds from dark to light—care being taken to remove the ground gradually—keeping, so to speak, on the safe side until success is assured. The ink used is much the same as that used for an etching or aquatint. It must be thoroughly worked into the whole of the plate, and the superfluous ink then wiped off, particular attention being paid to the clearing of the high lights.

From the time of its invention, by Ludwig von Siegen (whose first plate was made in August, 1642), until the early part of the nineteenth century copper alone was used for mezzotint engraving. In 1820, W. Say produced a portrait of Queen Caroline, engraved on steel, and in 1822 the use of this material was perfected by T. Lupton, and for some time it had a considerable vogue.

But it was never quite satisfactory. The burr was slighter, the indentations shallower, and it was much more laborious to work; while the dead black ink and white paper used, lent themselves only to a limited range of effects, seen at their best in the engravings of David Lucas, after Constable. Moreover, the number of possible impressions was soon found to be little more than could be procured from copper, and since the modern process of steeling plates has been perfected there remains no good reason for the use of steel.

Combinations with Pure Mezzotint. So far we have treated only of pure mezzotint—that is, this method used by itself in the engraving of a plate. But the labour involved therein was so great that the process had hardly attained its full development before other methods began to be used in combination with it, for the purpose, not only of saving trouble, but of avoiding the difficulty of defining outlines already alluded to. R. Earlom was one of the first artists to give attention to this endeavour; he frequently employed stipple etching, both as a groundwork and in order to elaborate his detail. In the "Liber Studiorum" (1807-1819) J. M. W. Turner employed generally a combination of etching and mezzotint, using the first process to bite in the strong lines of his composition before handing over the plates to be completed by mezzotint engravers. In the hands of Samuel Cousins, what is called mixed mezzotint was pushed to its utmost limits. He and his contemporaries made use of a heavy roulette as well as of special rocking tools, to work up the steel, and also used stipple etching and even aquatint. But these practices do not add to the real artistic merit of an engraving, and it is significant that they were but the prelude to an almost complete decay of the art. In our own day the art of pure mezzotint is experiencing a certain revival. The student should study the works of Valentine Green [11], J. R. Smith, J. and W. Ward, and J. MacArdell.

11. GEORGIANA, DUCHESS OF WESTMINSTER
From a mezzotint by V. Green after Sir Joshua Reynolds, 1780

Steel-facing. The printing powers of etched or mezzotinted copper-plates are very limited. The former class may produce 200 or 300 good impressions, but the latter (and the same applies to drypoint) cannot be relied upon to give more than from 30 to 100 prints of the best quality, owing to the rapid wearing away of the soft metal in the press. An attempt was made, as we have seen, to overcome this difficulty by the substitution of steel for copper, but without success. During the last two decades science has come to the rescue, and has provided a means whereby the actual engraving having been done upon copper, and full advantage taken of its unrivalled adaptability to this purpose, it may be invested with the durability of steel. The following concise description of the process (by Mr. Frank Short, A.R.A.) is taken from a pamphlet published by the Board of Education for use in connection with the Victoria and Albert Museum, and may be accepted as authoritative:

"Copper-plates when ready for printing are often covered with an exceedingly thin facing of steel (or iron) by suspending them in an iron solution and passing an electric current through it. The copper is covered, almost instantaneously, with a coating of hard, bright iron. From three to twenty minutes may be needed to obtain a sufficient thickness of iron, according to the plate and the current employed. Many solutions containing iron may be used, but the simplest method is to fill the tank with water, in each gallon of which is dissolved 1 lb. of sal ammoniac. A large iron or steel plate (the anode) is then placed permanently in it and attached to the positive pole of a battery (or other electric current), and a small piece of steel (generally an old file) is temporarily suspended opposite to it attached to the negative pole, until the bath becomes sufficiently full of iron to cause a deposit on a copper-plate when placed in it.

"The plate to be steel-faced is suspended by a strip of copper, soldered temporarily to the back, which serves both as a support to the plate and to complete the circuit of the electric current by contact with a brass rod connected to the negative pole of the battery. The quantity of current passing must be proportionate to the surface of the plate to be steel-faced, and its intensity may vary from 1½ volts to 6 volts. It is essential that the copper should be chemically clean before it is put in the bath, and it is necessary to remove it from the bath every few minutes to wash and gently polish the surface with a paste of fine whiting and water applied with a flannel, in order to keep the coating clear and bright.

"The steel-facing can be easily removed when desired by placing the plate in a mixture of nitric acid and water (1 acid to 7 water), which instantly dissolves the steel, leaving the copper untouched."

A good many wild statements have been made as to the effect of this process, and these need to be corrected. In the first place, it not only does not result in any loss of quality in the print, but it is impossible for the most accomplished expert to decide, from an inspection of proofs, whether they have been taken before or after the plate was steel-faced. Secondly, it does not prolong the life of the

12. CHRIST BEFORE HEROD
Woodcut by A. Durer, 1509

plate to the exent that has been claimed. It only makes it possible to produce some few hundred impressions—not thousands—of the best kind.

Wood Engraving. The old and beautiful art which made use of wood as a material for the printing of the artist's design has almost vanished under the stress of the competition set up by modern photographic processes. But it is so simple, and capable of effects so fine and characteristic, that many hope for its revival.

At the outset we have to indicate an essential difference between the wood block and that made of metal. In the former the printing is done by the upper surface of the block, exactly as with type. The process is, in fact, *relief printing*, as opposed to the *intaglio printing* of the metal plate, in which the paper is forced by great pressure into hollows excavated in the metal. As a consequence, wood blocks can be inserted in type without difficulty, and the paper shows no sign of that depression which is known as the plate-mark.

The Dürer Wood-cutting School. There are two methods of using wood for engraving. That employed by the great school of Albert Durer [12], and for many years afterwards, was executed upon blocks cut plankwise—that is, parallel with the grain. A wood of comparative softness, such as that of the pear-tree, was chosen. The drawing having been made or traced upon the smooth surface, the lines thereof were outlined with a knife, and the superfluous wood cut away with convenient tools, so as to leave the design intact. To this method it has been found convenient to restrict the term "wood-cutting." It is, in all essentials, that employed by the Japanese in their exquisite colour prints, and by many modern artists.

The Bewick Wood-engraving School. At the end of the eighteenth century it was found that boxwood, from its extreme hardness and closeness of grain, was especially suitable for a use to which the term "wood-engraving" is well applied [13]. The blocks were cut, not with the grain, but across it. The drawing was made upon the block, on a surface prepared for the purpose with Chinese white, and the engraving executed with burins of several sizes, practically the same as those employed by the line engraver on metal. It will be evident that the driving of the burin through the wood produces a white line, the ink being held by those portions of the block untouched by the tool; and this fact was made use of by Bewick and the best of the nineteenth century wood-engravers to produce their effects. Prints by these artists will be seen, on close examination, to consist of a series of white lines or dots, each made with deliberate purpose of expressing drawing. But the burin was also used for facsimile engraving, with a result similar to that of the knife, developing in this respect into a laborious reproduction of the exact lines of the artist's work, as compared with the individual translation of it secured by the white-line method.

The student should refer to the work of Bewick as exemplifying the latter; that of Charles Keene in "Punch" is an admirable exposition of the former. Millais and Keene, indeed, largely used the free line, but most of the other artists of that splendid epoch of book illustration made their drawings in wash or closely stippled pen drawing, leaving to the engraver a considerable latitude in the interpretation of tone. This he did by "cross-hatching"—picking out the spaces between the inter-sections of crossed lines; and to the general adoption of this mechanical device much of the inferiority of modern work is due.

Continued

13. CLEOPATRA
From a wood-engraving by Dalziel Bros. after Sandys

CORLISS AND MARINE ENGINES

Corliss Valves. Examples of Engines. Cylinders. Marine Engines. Examples. Details. Leading Dimensions

By JOSEPH G. HORNER

CORLISS engines, deriving their name from that of the American, George H. Corliss, their inventor, have been modified in many ways by engineers in England and on the Continent. Their valves were a great advance on the old slide valves when engines of large dimensions were concerned, and have enjoyed an immense amount of success. But it is at least doubtful if they will not in time be superseded by the engines with drop valves and with piston valves. The general outlines of a Corliss engine are seen in **58**, which shows a pair of compound horizontal mill engines, of 1,800 indicated horse-power, by Wood Bros., of Sowerby Bridge. The engines are used for mill driving, the fly-wheel being grooved for cotton ropes, sets of which drive to different rooms in the factory.

The special feature of the Corliss engines is the shape and disposition of the valves. They are long valves, cylindrical in section where they fit their seatings, and their motion is only that of partial rotation. Figures **59** and **60** show the steam and exhaust valves respectively for **58.** They admit steam through passages nearly as long as the diameter of the cylinder. The passages for steam and for exhaust are distinct and separate, one for steam, and one for exhaust, at each end of the cylinder.

The details of operation, however varied, have two features in common: either a *wrist plate,* or its equivalent in lever arrangements, with dash pots, and pistons, or springs. The first imparts the partial rotary movement to the valves: the second close the valves sharply immediately following release, by detents.

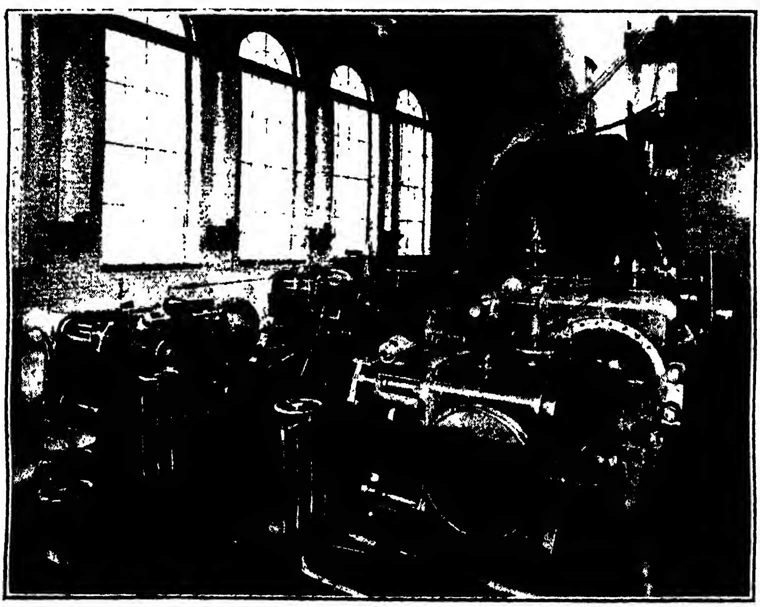
The gradual opening and closing of the common slide valve is not an ideal arrangement. The rapid and full opening to steam and to exhaust, and sharp closing of the same in the Corliss valves are more economical, preventing both excessive wire drawing and back pressure, and avoiding excessive clearance. The valves are simpler than balanced slide valves are, and work with less absorption of energy.

Robey Engine. Figure **61** illustrates a Corliss engine by Robey & Co., Ltd., in external elevation and plan, from which a good idea can be gathered of the design which is most commonly adopted—that of a wrist plate.

The valve gear is worked primarily from the eccentric A. Its rod oscillates a lever B, which is pivoted at *a*, so imparting a to-and-fro movement to the rod above, which rocks the wrist plate thus through an arc of a circle on its pin. Pivoted to this plate with pins are levers EE, which actuate the steam supply valves, and the levers FF that operate the exhaust valves. The valve stems of the steam valves are seen at *cc*, in the plan view, within their bonnets. The function of the wrist plate is to impart a fixed amount of movement to the valve spindles. But this movement is arrested, or *tripped*, at a certain stage, corresponding with the moment of cut-off, at which instant the steam valves are sharply closed by a piston in the dash pot G. The governor J acts on the steam valves through the rod K. The trip levers *dd* effect the connection of the valves by the notch in *d* fitting over the catch *e*, and the release by the arm of the lever coming in contact with the projection *f*.

The designing of the details of Corliss valve gears involves much graphic construction, supplemented by trials. The different types are known by different names, besides which manufacturers have introduced many minor alterations.

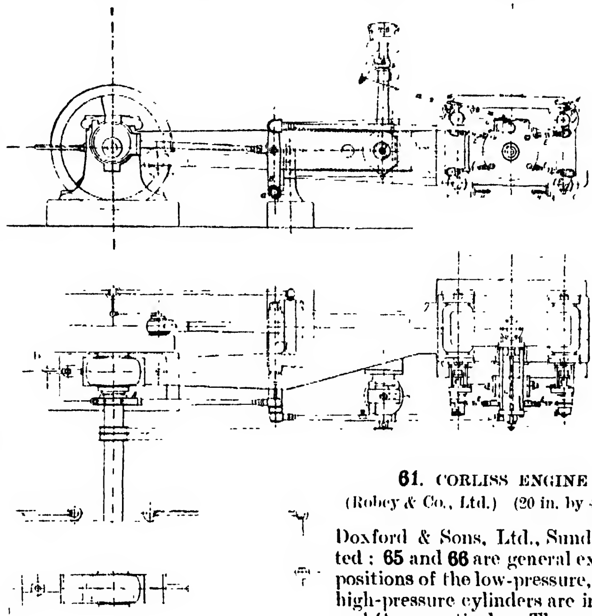
Cylinders. Figure **62** shows the cylinder of the Robey engine in longitudinal and transverse sections, which is an excellent illustration of the way in which a large cylinder is built up. AA and BB are the seatings for the steam and exhaust valves. The cylinder is built up of the plain body C, the ends DD containing the seatings, and fitting to the body with flanges, E is the back cover, and



58. COMPOUND CORLISS CONDENSING ENGINES—1800 H.P. (Wood Bros.)

F the hard liner, between which and the body is the jacketed space. The bore is 20 in., and the distance between covers 4 ft. 11¾ in., the stroke of the engine being 40 in.

Another cylinder is shown in **63** by the firm of H. Bollinckx, of Brussels, who make a speciality of these engines. The steam and exhaust seatings are cast partly in the end covers A, B, and partly in the jacket C at one end, and partly in the body D at the other end. The fitting of the body and jacket will be noted. At the end *a* there is a rigid connection between the two by a flange and bolts at the other end, *b*, the parts are free to slide under varying expansions with differences of temperature. The end covers are jacketed connections being made as seen between the covers and the body jacket.



61. CORLISS ENGINE
(Robey & Co., Ltd.) (20 in. by 40 in.)

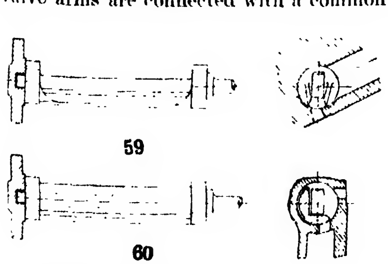
Fleming Engine. A special type of Fleming Corliss engine by the Harrisburg Co. is shown in longitudinal section in **64**. It embodies a departure from long-established practice. Hitherto, Corliss engines have mostly been of long-stroke design. This is of short-stroke type, following in this respect designs of vertical high-speed engines.

The engine is a tandem compound, and both cylinders are fitted with Corliss valves. Two eccentrics are provided. One actuates the two steam admission valves, the other the two exhaust valves. The motion of the valves is transmitted through bell cranks and independent rocker arms. The bell cranks are coupled together with adjustable links. To the short arms of the bell cranks a link is attached, which transmits their movements to a valve arm secured to the projecting valve and stem (not indicated). The effect is that the valves have an accelerated rate of movement at the points of opening and closure. The exhaust valve arms are connected with a common link.

Marine Engines. The term *marine engine* is too vague to convey much beyond a general idea of the type. It is now used always in the case of ocean-going steamers to denote the inverted cylinder type. But the compound engines of a yacht have little more than this in common with the engines of a liner or a battleship.

A triple expansion marine engine by the Pallion Engine Works of Wm. Doxford & Sons, Ltd., Sunderland, is illustrated: **65** and **66** are general external views. The positions of the low-pressure, intermediate, and high-pressure cylinders are indicated by A, B, and C, respectively. They are carried on cast-iron frames DDD, which are supported by the base plate E. The frames D have slipper faces formed for the crossheads F, whence the connecting rods G drive to the crank shaft H, which has its bearings in the base plate E. The eccentric rods J, K, L actuate the valves for the low, intermediate, and high pressure cylinders respectively. The first two are double-ported slide valves. The last is a piston valve. The rods and eccentrics are duplicated for reversals for driving ahead or astern. The shifting links are indicated at M, the drag links at N, and the weigh shaft at O. The mass of these is so great that a simple hand lever would be useless. A hand wheel P and worm gear Q therefore operate the weigh shaft through the rod R and its lever.

The surface condenser S is built into the standard framings, with economy of space. The air and circulating pumps indicated at T are bolted to it, and their piston rods are actuated by the connecting rods U and levers V from the crosshead of the low-pressure cylinder by the pin W and connections XX: at Y is seen the turning gear for giving the engines initial movement. At Z is a starting engine, driving to a crank for effecting reversal for ahead and astern movements, and being



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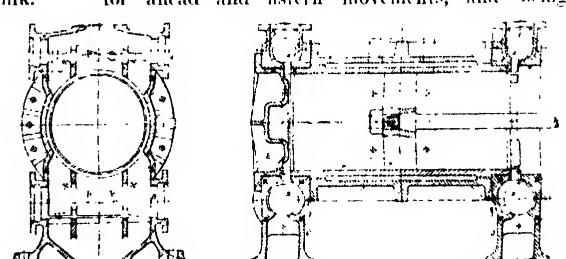
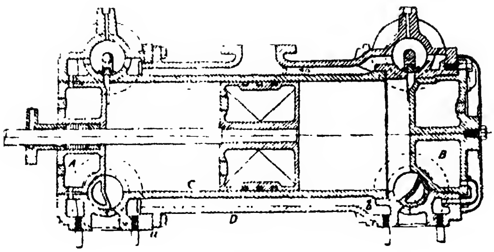
STEAM AND EXHAUST VALVES OF CORLISS ENGINE



62. TRANSVERSE AND LONGITUDINAL SECTIONS OF CORLISS CYLINDER



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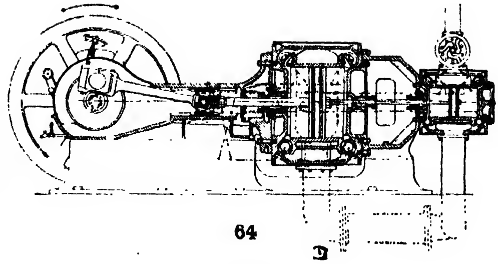

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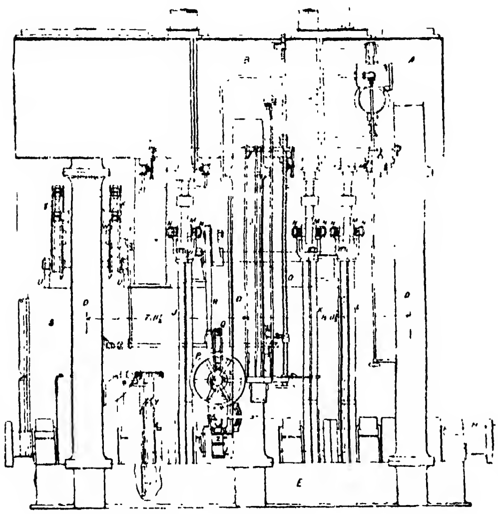

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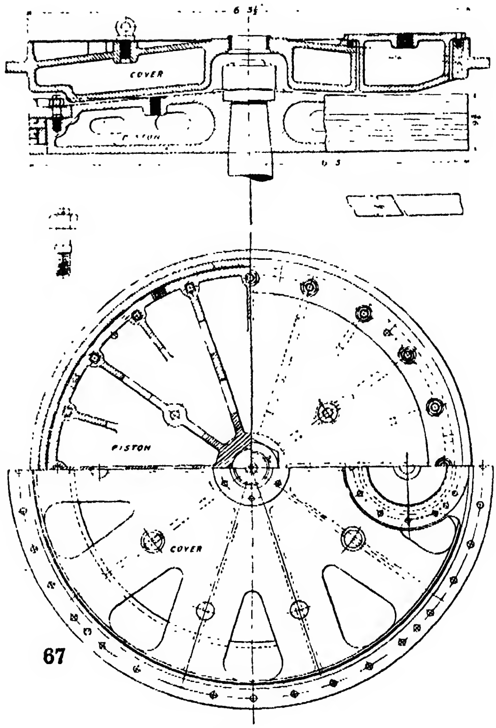

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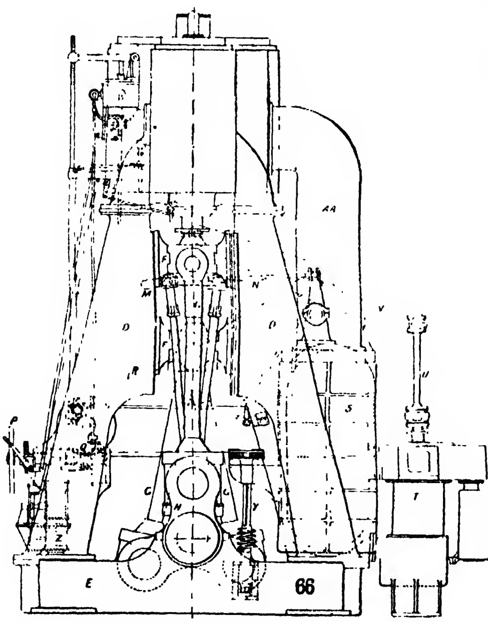

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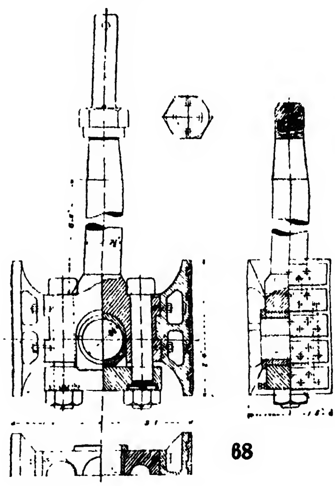

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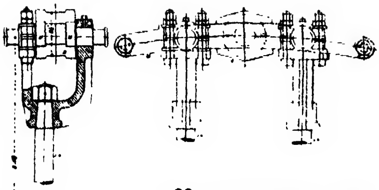
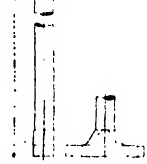
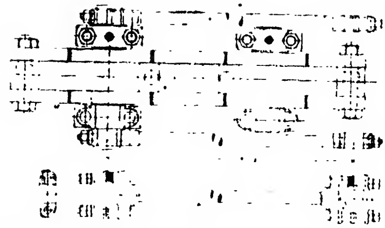
ENGINE DETAILS

63. Corliss cylinder **64.** "Fleming" Corliss engine **65.** Front elevation of triple expansion marine engine (Wm. Doxford & Sons, Ltd.) **66.** End elevation of engine **67.** Piston and cover of low-pressure cylinder **68.** Piston rod and crosshead of marine engine





69. ECCENTRIC ROD AND LINK OF MARINE ENGINE



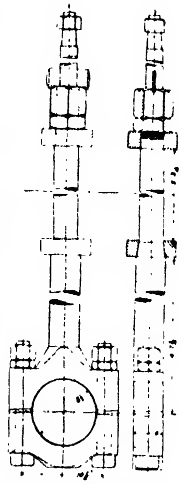
70. REVERSING LINKS OF MARINE ENGINE

auxiliary to the hand gear P, Q, R. The numerous small handles and levers are for passing live steam into the cylinders to warm them up, and for operating drain cocks, etc. These are usually located close to the reversing hand wheel and engine. From this general description we may pass to consider some of the principal details, which, however, can be only partially illustrated in a portion of an article, owing to the enormous amount of items in such an engine.

Details. The three cylinders are cast separately, and bolted together by flanges. They measure respectively 27½ in., 45½in., and 75 in. in diameter, and the piston stroke is 4 ft. 6 in. The high-pressure only is fitted with a liner. The casing for the piston valve is cast with this cylinder. The valve chests for the double-ported valves of the intermediate and low-pressure cylinders are formed in their castings. Feet are cast on each cylinder for bolting it to its A standards. The exhaust pipe, AA, to the condenser is bolted to the low-pressure cylinder. In these large engines the valves, pistons and covers are massive ribbed castings, very different from those in the smaller engines we have hitherto illustrated. Figure **67** shows the piston and cover of the low pressure cylinder. Covers and pistons are hollow, to ensure rigidity and strength without excessive weight, for the pressure on pistons and covers amounts to many tons. Junk rings and spring rings are fitted to the pistons. Lifting screws are fitted to enable the crane to lift covers and rings out for examination and repairs.

The piston rods [**68**] measure 7½ in. diameter, and the crossheads are 2 ft. 4 in. in length, by 1 ft. 5 in. in width. White metal facings are used. Details of the valve gears are shown in **69** to **71**. In **69** M is the link, similarly lettered in **65** and **66**: A is the sliding block which is embraced by the end of the valve rod [**71**]: J, K, L are the eccentric rods; NN the drag or reversing links; compare with **65** and **66**.

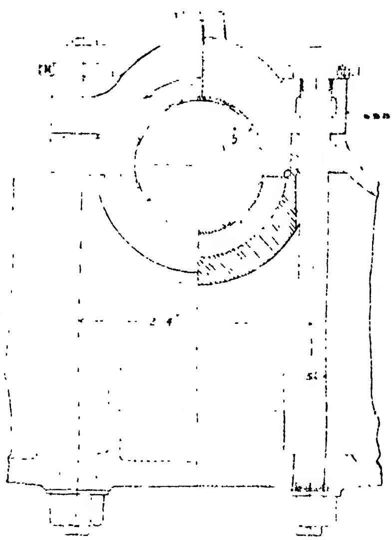
The enormous dead weight of the reciprocating masses is largely counterbalanced by the three-cylinder arrangement, in which the cranks are set 120° apart. The crank shaft, which is 1 ft. 3 in. in diameter, is built up in the manner shown in **73**. Lengths of shaft with flanges are coupled and bolted as seen in the detail at A. The crank webs, B, are fitted over the opposite ends, and over the crank pins. These are shrunk fits in the first place—that is, the parts are turned and bored with a slight excess in size of the turned portion, and the webs are then warmed, slipped over, and tighten in cooling. Turned keys are afterwards inserted to prevent possible loosening in working.



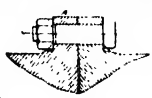
71. VALVE ROD OF MARINE ENGINE

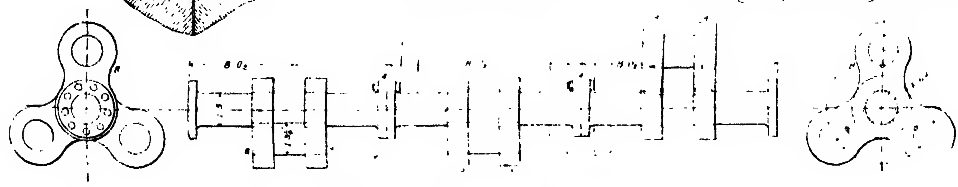
The frames or columns DD [**65**] are massive hollow castings, though having a quite solid appearance from the outside. Suitable facings are provided on them for the reception of the cylinders, and feet for the bedplate, and manholes. The bedplate, or soleplate, E, is a hollow casting in one piece, and having the shaft bearings, six in number, cast with it, shown in detail in **72**, to receive the frames.

The condenser, S [**65** and **66**], is shown separately in **74** along with the columns with which it is cast. The circulating tubes are inserted by ferruling into the tube plates bolted within the main casting. The distance between the tube plates is 14 ft. There are 1,868 tubes, ¾ in. diameter outside, giving a cooling surface of

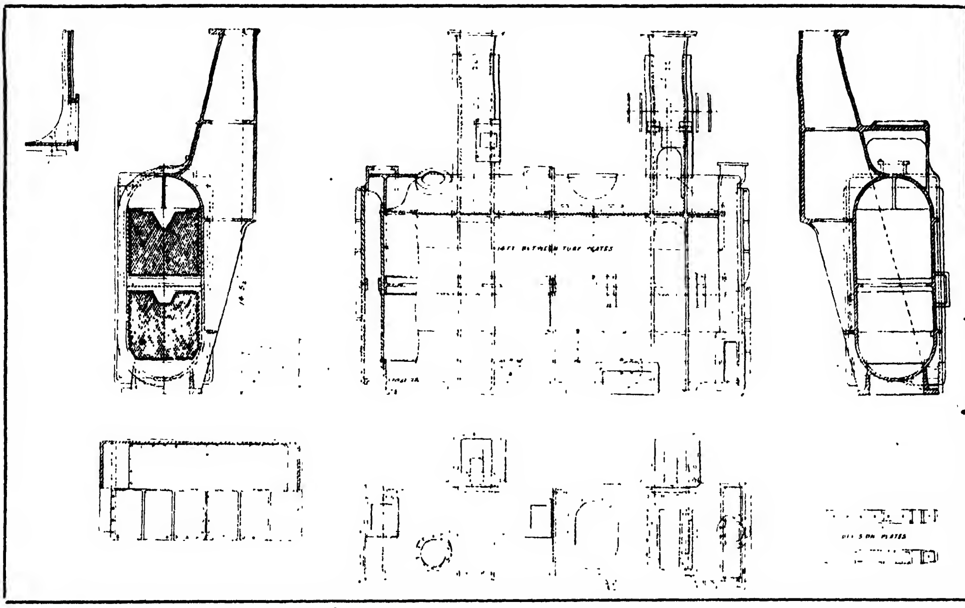


72. MAIN BEARING IN SOLEPLATE OF MARINE ENGINE





73. THREE-THROW CRANK OF MARINE ENGINE



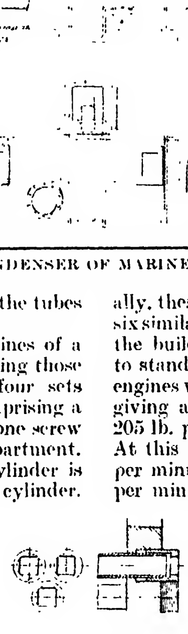
74. CONDENSER OF MARINE ENGINE

5,754 square ft. The method of fastening the tubes is shown in 75.

Examples of Engines. The engines of a big liner are of immense proportions. Taking those of the Kaiser Wilhelm II., there are four sets of these, each complete in itself, each comprising a quadruple expansion set. Two sets drive one screw shaft. Each set is fitted in a watertight compartment. A peculiarity is that the high-pressure cylinder is placed tandem above the intermediate cylinder. The diameters are as follows: High-pressure, 950 mm. (37·40 in.); first intermediate 1,250 mm. (49·21 in.); second intermediate 1,900 mm. (74·80 in.); low-pressure 2,850 mm. (112·21 in.). The common stroke is 1,800 mm. (70·86 in.). The ratio of cylinders is 1, 1·73, 4·9. Each engine set has its own condenser, with 11,733 square ft. of cooling surface, twin air pump, circulating pump, feed pump, and feed heaters and various pumps. So immense is the installation that the steam cylinders in the vessel total to about 140.

Engines of Battleships. The engines of the Japanese battleship Katori, built and engined by Messrs. Vickers, Sons & Maxim, Ltd., consist of four cylinder triple expansion engines, of which there are two sets. Each set has one high-pressure cylinder, 35 in. in diameter, one intermediate of 56 in., and two low-pressure cylinders, each of 63 in. diameter, with a 48-in. stroke. The engines work at 200 lb. initial pressure, the boiler pressure being 230 lb. The valves on the high-pressure and intermediate cylinders are of piston type, those on the low-pressure are double-ported flat valves. The condenser has a total cooling surface of 17,000 square ft.

The following relates to the engines of the armoured cruiser Duke of Edinburgh. Incidentally, these are of interest because these, with those of six similar cruisers of which the Admiralty sanctioned the building, have their six sets of engines made to standardised gauges, templets, and jigs. These engines were designed to develop 23,500-horse power, giving a speed of 22·33 knots. Steam is used at 205 lb. pressure when at the main regulating valve. At this pressure the engines make 135 revolutions per minute, equivalent to a piston speed of 945 ft. per minute. The cylinders are ranged thus: The high-pressure has one low-pressure adjacent. On the other side is the intermediate pressure cylinder, and beyond that the second low-pressure cylinder. These four cylinders constitute a set, and two such sets are placed in separate watertight compartments on opposite sides of the vessel. The diameter of the high-pressure cylinder is 43½ in., that of the intermediate 69 in., and the two low-pressure cylinders are 77 in. in diameter. The stroke is 42 in. To facilitate balancing, the combined horse-power of the two low-pressure cylinders is equal to that of the high-pressure, and of the intermediate pressure cylinder separately. In these engines all the cylinders are steam jacketed. The liners for the high-pressure and intermediate are of forged steel, but those for the low-pressure cylinders are of cast iron. Cast steel is used for pistons, and cylinder covers. The high-pressure cylinder is fitted with one piston valve, the intermediate cylinders with two. Flat slide valves are used for the low-pressure cylinders with relief wings at the back. Starting valves are provided to admit steam directly to the intermediate and low-pressure cylinders. The condensers serve for the main and auxiliary engines. There are two in each engine-room, each with a cooling surface of 7,009 square ft



75. FASTENING OF CONDENSER TUBES

Continued

SHORT DICTIONARY OF PRIME MOVERS & STEAM BOILERS

ACTUAL HORSE-POWER—Horse-power obtained by the indicator, minus the power absorbed by the engine friction.

Adhesion—Specifically, the measure of the weight resting on the wheels of locomotives.

Air Pump—A pump employed in all condensing engines for removing the mixed air and water from the condenser.

Asbestos—A fibrous mineral, which, owing to its heat-resisting character, is prepared for use in engine packings and joints.

Atmospheric Engine—An early type, in which the pressure of the air moved the piston downwards against a partial vacuum.

Atmospheric Line—The line on an indicator diagram which divides the steam area from that of vacuum.

BACK PRESSURE—Pressure opposed to the movement of the piston in a cylinder, due to steam not wholly exhausted.

Balloon Boiler, or Haystack Boiler—An obsolete form, of a dome shape, externally fired.

Barring Engine—A small engine used for starting a very large engine.

Beam Engine—A vertical engine having the piston-rod operating one end of a pivoted beam, and the connecting rod at the other.

Bed Plate—The base, usually a casting, which carries all the mechanism of an engine.

Blast Pipe—In a loco. boiler, the pipe through which the steam exhausts into the chimney, so creating a sharp draught in the fire-box.

Blow-off—The periodical discharge of steam, water, and sediment from a boiler.

Boilers—The steam generators for engines. Internal combustion engines require no boilers.

Brake Horse-power—Horse-power as measured by a friction brake.

CALORIE—The French unit of heat, or that which will raise 1 kilo. of water through 1° C. between the temperatures of 0° C. and 1° C.

Carnot's Principle—Postulates the law that the work done by a heat engine is wholly a question of temperature.

Central Valve Engine—An engine in which the distribution of steam is effected by openings in the piston-rods.

Cheval-Vapeur—French horse-power, or 4,500 kilogrammes lifted 1 metre high per minute, equals 0·9863 English horse-power.

Chimney—The function of a chimney is to produce a draught in the furnaces and flues of a boiler. It acts by virtue of the difference in the specific gravities of the hot air within and the cold air without.

Circulating Pump—A pump which forces the cooling water through the tubes of surface condensers.

Clark's Process—The best known process for softening the feed-water for boilers by the addition of lime thereto.

Clearance—The space left between the face of a piston at the termination of its stroke and the inner face of the cover, to prevent actual contact. Freedom to exhaust in an engine cylinder.

Clinkering—Cleaning the grate bars of boilers periodically.

Closed Ashpit—Signifies that the ashpit alone receives air under pressure.

Closed Stokehold—The stokehold enclosing the boiler front of a marine engine which receives the supplies of air through fans only.

Cold-water Test—The hydraulic pressure test applied to steam boilers with cold water.

Compound Engine—An engine having two or more cylinders in which steam works expansively in succession.

Condenser—The vessel in which the exhaust steam from an engine or engines is condensed to water.

Condensing Engine—One in which the exhaust steam goes into a condenser instead of into the atmosphere.

Connecting Rod—The rod which connects the piston and its cross head to the crank of the flywheel shaft.

Corliss Engine—One in which separate valves are used for the entering and exhausting steam.

Cornish Boiler—A horizontal boiler with a single furnace flue.

Cornish Engine—A special type of beam engine, used first in the Cornish mines.

Corrugated Furnace—A type of boiler furnace which is stiffened against collapse by alternating ridges and depressions.

Crank-pin—The pivot on which the free end of the connecting rod takes its bearing, being the end opposite to the crank shaft.

Cushioning—The elastic counter-pressure against a piston, bringing it to rest by the steam admitted through the opening to lead.

Cut-Off—Arresting the supply of steam to the interior of a cylinder.

Cut-off Valve—A supplementary slide valve on the back of a main valve for working steam at high expansion.

Cylinder—Specifically the vessel in which the movements of an engine piston are coerced.

DAMPERS—Sliding, or swivelling plates which regulate the draught through boiler flues.

Dead Centres—When the axis of the piston-rod, the crank-pin, and the crank-shaft are in one plane the engine is on dead centres.

Dead-weight Safety Valve—One in which the loading is done directly by the imposition of annular weights.

Double Acting—Expresses the case of pistons which are subjected to pressure on opposite sides alternately.

Dry Steam—Steam which is only saturated with moisture by contact with the water from which it is generated.

Duty—The duty of an engine is the number of foot pounds obtained by the burning of a bushel of good coal. The term is nearly obsolete.

D-valve—The form of slide valve which has a section nearly like that of the letter **D**.

Dynamometer—A mechanism by which the power given off or absorbed by a prime mover or machine is measured.

ECCENTRIC—The agent by which the rotary motion of the crank is converted into the reciprocating movement of the slide valve.

Eccentric Sheave—The body of an eccentric, keyed on the crank-shaft.

Eccentric Straps—The bands which encircle the sheave, and transmit its motion to the eccentric rods and slide valve.

Economiser—A nest of pipes in which the feed-water for boilers is heated by the waste gases from the boiler.

Elastic Force—The expansive, or heat energy of a gas.

Enclosed-type Engine—Stationary engines having the working parts wholly enclosed, and running in an oil bath.

Evaporative Power—It is usual to estimate the value of different fuels by the relative quantities of water which they will evaporate.

Exhaust Steam—The waste steam from an engine cylinder.

Expansive Working—A definite volume of steam or gas doing work on a piston by the force of its own expansion.

External Firing—The application of heat outside a boiler shell. Now obsolete.

FEED PUMP—The pump which supplies feed-water to boilers.

Feed-water Heater—A type of economiser in which the feed is heated before being passed into the boiler.

Ferrules—Rings used for fastening the tubes of boilers and condensers into their plates.

Final Pressure—The pressure of steam in a cylinder in the last stage of its expansion.

Fire-bars—The grate bars in a boiler furnace.

Fire-box—The furnace of a locomotive or a vertical boiler.

Forced Draught—Air for combustion in steam boilers which is introduced under pressure by fans.

Furnace Flues—The furnaces of horizontal boilers, placed within the shell.

Fusible Plug—A plug of easily fusible alloy, inserted in the top of a boiler furnace, which melts and lets the water out if the water runs dangerously low.

GAS ENGINE—Any engine using gas, which may be town, or producer, or blast-furnace gas.

Gaskets—Packings of hemp rope used in stuffing boxes.

Gauges—Instruments for indicating pressure of steam, and vacuum, and water levels.

Governor—A device which automatically reduces variations in speeds of prime movers.

Grate Area—The superficial area of the fire-grate of a boiler.

Guides—Flat bars, or cylindrical tubes by which the movements of the crosshead are coerced.

HEAT ENGINE—Any prime mover which is actuated by heat contained in a gaseous fluid.

Heating Surface—The area of a steam boiler which is exposed to flame and hot gases on one side and water on the other.

High-pressure Engine—Any engine which uses steam at a pressure higher than the ordinary at a given period. The high pressures of a few years ago would not be classed as such now.

High-speed Engine—One which has a high rotative or a high piston speed in comparison with ordinary engines. The term is therefore relative.

Horse-power, or H.P.—33,000 lb. lifted 1 ft. high per minute.

Hot-air Engine—One in which atmospheric air is used, which is alternately heated and cooled.

Hot-water Test—The hydraulic pressure test applied with hot water to steam boilers.

Hydraulic Engine—One, the motive-power of which is water under high pressure.

INDICATED HORSE-POWER, or I.H.P.—The horse-power of an engine obtained by an indicator.

Indicator—An instrument for recording on a card the varying pressures of steam in a cylinder.

Indicator Diagram—The diagram traced by an indicator.

Induced Draught—Boiler draught induced by a fan placed in or near the chimney in the course of the flues.

Induction Port—The opening of the passage through which steam is admitted to a cylinder.

Ignition—The act of firing the charge in the cylinder of a gas engine.

Injector—A device for supplying feed-water to a boiler.

Internally Fired Boiler—One which has its furnace within the shell or water casing.

JACKETING—Surrounding an engine cylinder with a chamber supplied with steam.

LANCASHIRE BOILER—A two-flued horizontal land boiler.

Lap—The distance by which the edges of a slide valve when in middle travel overlaps the induction ports.

Latent Heat—The heat which disappears during the vaporisation or the fusion of a substance, without raising the temperature.

Lead—The distance by which the edge of a slide valve opens the exhaust port at the termination of the piston stroke.

Liner—The lining tube of hard metal fitted within many engine cylinders.

Link Motion—The arrangements of slot link, eccentrics, and rods used for actuating the movements of slide valves.

Live Steam—Steam as it comes from the boiler.

Lubricators—Vessels which contain liquid or solid lubricants for the supply of bearings.

MAIN BEARINGS—The bearings of the crank shafts of engines.

Mean Pressure—The average of the entire range of steam pressures in a cylinder from the moment of inlet to that of final exhaust.

Metallic Packings—The steam-tight joints made in stuffing boxes with elastic rings of metal.

NEWCOMEN'S ENGINE—The pattern on which the early steam engines were built. It was operated by atmospheric pressure.

Nominal Horse-power (N.H.P.)—A commercial term, a survival of an early practice, of little value under changed conditions.

Notching-up—In link motions, pulling the link nearer to the centre, with resulting earlier cut-off and higher expansion.

OSCILLATING ENGINE—A nearly obsolete type, in which the oscillation of the cylinder was made to operate the slide valves.

PACKINGS—Materials used in stuffing boxes for rendering piston and valve rods steam-tight in their holes.

Piston Speed—The speed of movement of a piston measured in feet per minute.

Piston Valve—A sliding valve which is of cylindrical section.

Prime Mover—A machine which utilises the forces of Nature for the service of man.

Priming—The mixing of particles of water with steam.

Producer Gas—Gaseous fuel generated by the combustion of solid fuel in gas producers of various kinds.

QUADRUPLE EXPANSION ENGINE—One in which the steam is expanded through four successive cylinders before exhausting to the condenser.

RECEIVER—The steam chest, pipe, or special vessel through which steam passes from one cylinder to the next in compound engines.

Return Tube Boiler—The marine, or Scotch boiler, in which the smoke tubes return over the top of the furnace to the front of the boiler.

Reversing Rolling Mill-engine—A special design used for rolling steel plates and sections, the direction of movement being reversed between each pass.

Right-hand Engine—One in which the flywheel stands to the right, when viewed from the front of the engine.

SAFETY VALVE—A valve on a boiler which opens when a definite steam pressure is exceeded, so relieving the steam pressure.

Saturated Steam—Steam in contact with water of the same temperature.

Scale—Deposit which hardens on the water side of the plates of steam boilers.

Setting of Boilers—Fixing land boilers over their flues, and seatings of brickwork.

Slide Valves—Valves occurring in numerous forms, the function of which is to control the supplies of steam to cylinders, as distinguished from lift or drop valves and rotating valves.

Slipper—Slipper bars are guide bars; a slipper block is a piston crosshead.

Slot Link—The link through which variable expansion, and reversals are effected.

Smoke—Particles of solid carbon suspended in unburnt gases, and vapour of water. Its proper combustion is the object of many devices in boiler engineering.

Soda—Used for preventing scale in boilers.

Split Draught—The arrangement of flues in Lancashire boilers in which the products of combustion are divided at the back, and pass round to right and left.

Stationary Engine—One fastened to foundations.

Steam—The vapour of water, which, by virtue of its elastic energy, communicates motion to a piston or rotor.

Steam Chest—*see valve chest.*

Superheated Steam—Steam made hotter than the temperature at which it is generated.

Surface Condenser—One fitted with tubes in the steam space, and through which the cold water circulates. It differs in this respect from the jet condenser, which receives one jet of water.

TAIL ROD—A rod in continuation of a piston, or valve rod, but on the opposite side. Its function is to steady the movements of the piston, or valve.

Tandem Engine—A compound engine, the cylinders of which are in the same longitudinal axis.

Thermal Unit—The amount of heat required to raise 1 lb. of water 1° F. is the British Thermal unit, and is equivalent to 772 foot-pounds.

Three-cylinder Engine—Specifically an engine in which the cylinders are arranged round a circle, with their axes 120° apart.

Throttle Valve—A valve which opens and closes the supply of steam from a boiler to an engine.

Throw—Twice the radius of an eccentric or a crank.

Tractive Force—The power exercised by the pistons and driving wheels of a locomotive to move a train.

Travel—The length of movement of a piston or a valve.

Triple-expansion Engine—One in which the steam is expanded from one high-pressure into two low-pressure cylinders in succession.

Trip Lever—A lever which lifts drop valves through a certain distance, and then allows them to close sharply.

Try Cocks—The steam and water-cocks on a boiler which indicate the highest and lowest water level allowable.

Tube Expander—An appliance used for tightening the fire-tubes in multitubular boilers.

Tubes—Tubes of brass, steel, iron, or copper are used in boilers to convey the heat from the fire-box through the water to the smoke-box.

Tube Surface—The total area of the exterior surfaces of condenser tubes.

Tubular Boiler—Any boiler provided with nests of tubes to increase the heating surface.

UNDERTYPE ENGINE—A fixed engine with a locomotive type of boiler, in which the engine is fixed beneath the boiler.

Unit—A standard for calculations—as the unit of heat, of work, of mass, of strength, or of stress.

VACUUM—The amount by which the pressure of a condenser is below that of the atmosphere. It is measured in pounds, or in inches of mercury.

Valve—The agent by which the opening of steam and exhaust passages is controlled. It may be a slide valve, flat, or of piston type, or a drop, or a partly rotating valve. Or a main, or a cut-off valve.

Valve Chest or Steam Chest—The casing which encloses a slide valve.

Valve Diagrams—Diagrams made to show graphically the cycle of action of valves.

Valve Setting—Adjusting valves in relation to the crankpin and the eccentric sheave.

Variable Expansion—The expansion of steam in a cylinder caused by alterations in the opening of the throttle, or in the point of cut-off of the valves.

Varying Travel—The travel of a slide valve which is varied momentarily by expansion gear, instead of being constant by a fixed eccentric only.

Vertical Boiler—A cylindrical boiler having its axis set vertically.

Vertical Engine—An engine having the axis of its cylinder set vertically.

WAGGON BOILER—An obsolete form, deriving its name from its cross section. It was externally fired.

Wall Engine—A steam engine, the bed-plate of which is bolted to a factory wall, the axis of the engine being vertical.

Waste Heat—Residual heat from furnaces which, formerly lost, is now frequently utilised in warming feed water, or brickwork, or air and gas.

Water Pressure Engines—Engines of rotary or reciprocating types which are operated by water under pressure.

Water-tube Boiler—A steam boiler in which the fire plays around nests of small water-tubes variously arranged.

Weight Shaft—The shaft which carries the lever for lifting and lowering the slot links of valve gears.

Wheel Draught—The arrangement of flues in Lancashire boilers, in which the products of combustion pass round the boiler in one direction.

Winding Engine—A hoisting engine designed specially for hauling mine waggons up inclines.

Windmill—A wind engine, the chief use of which now is to drive well pumps in country districts.

Wire Drawing—Steam is wire-drawn when passages are made too small to permit it to enter with freedom into the cylinder.

Wire Gauze—Finely-woven wire used for making steam-tight joints between flanges.

Woolf Engine—An early compound engine in which the crank-pins were set 180° apart.

Wrist Plate—The rocking disc which transmits motion to the valve spindles of Corliss engines.

BONE AND IVORY CARVING

Prehistoric Forms of Carving. Working in Ivory. A Lost Art. Horn and Shell Carving. Shell Cameos

Group 2
CARVING
4

Continued from page 6138

By F. WELLESLEY KENDLE

THE presence of carved and engraved bones amongst the tertiary deposits of Europe and America constitutes the strongest link in the chain of evidence that connects man with this remote period [59 and pages 2479 and 2480].

Bone Carving. On account of the hardness of its outer layers and the cancellous structure of the inner, deep carving is not suitable to this material. Having sawn the bone into convenient slabs, rough out the design with the parting tool and very quick gouges: rough carve with flat gouges and firmers, finishing with the assistance of rifflers and files; sandpaper then comes into play to remove scratches and tool marks, the whole being finally polished with the help of putty powder.

Bone is easily dyed; it is even possible to impart a red colour to it during the lifetime of the animal by feeding it with madder (*Rubia tinctorum*). Bone is used as a cheap substitute for ivory for knife-handles, chessmen, thimbles, and other small articles: but it soon discolours, and the comparative coarseness of its grain renders it useless for the production of delicate objects.

Ivory Carving. The antiquity of this handicraft is also undoubted, for, like bone carving, it dates back to prehistoric ages. A contemporaneous portrait of a mammoth [60] carved most realistically upon a fragment of fossil ivory has been unearthed in the Madeleine cave, Dordogne. Coming to more modern times, specimens have been preserved that teach us that the art has been largely practised by nearly every known civilised nation.

Ivory is a fine-grained, hard, dentine-like substance composing the tusks of both the African and the Indian elephant, together with those of the walrus and the narwhal. The molars of the elephant yield a less dense variety and those of the hippopotamus a peculiarly hard kind, which was used by dentists. All the above are known as green or live ivory, distinguishing them from the white, dead, fossil, or Siberian ivory obtained from the remains of the extinct mammoth. The density, toughness, elasticity, durability, colour and beautiful figure of ivory, its absence of appreciable grain, and its capacity for receiving a high degree of finish, eminently fit it for the carver's hands.

The Tools for Ivory Carving. The tools used for carving ivory are similar in character to those of the wood-carver, but smaller and stouter, with less tapered edges, like turning and engraving tools. The design is drawn upon the ivory in Indian ink, as much as possible of the surface is removed with the saw, the pattern is grounded out, and the contours roughly hacked into shape. The ordinary cutting stroke is too tedious to be of practical service. Waste is removed more quickly by holding the tool upright and advancing first one corner of it and then the other in a zig-zag fashion, exerting firm pressure the while, nibbling the ivory away little by little. Drills and tiny points are next used for the deeper portions, and files for the shallower. Indeed, the file is such an important tool that "ivory filing" would be a more appropriate term for the art than "ivory carving." Ivory is more cheaply worked by worrying away its substance with revolving burrs and drills, afterwards finishing as described below.

Polishing, Engraving, and Repairing. The work is polished in three successive stages: (1) No. 0 glasspaper; (2) putty powder, pumice, or fine siliceous earth; and (3) a revolving brush fed with whiting and water.

Ivory may be easily engraved, the pattern being rendered visible by rubbing in Indian ink or indigo, and papering the surface to bring up the lines clearly and sharply.

Broken ivories can be repaired with fish glue, provided the broken surfaces are not greasy, in which case, cleanse them with sulphuric ether, alcohol, or benzene. Warm both fragments, apply as little glue as possible and exert firm pressure till thoroughly set. Ivory dust or shavings mixed with fish glue may be used for building up bruises, chips, or deep scratches.

Ivory carvings are apt to discolour unless exposed freely to both light and air.

Imitation and the Forgotten Moulded Ivories. Very fair imitations of old ivories may be made by covering carved wood with three or four coats of very pale chrome enamel, re-stamping the groundwork, and flooding the depressions with Vandyke brown; or by making casts in a creamy yellow plaster of Paris, boiling them in spermaceti or hard paraffin, stippling the ground and lining the furrows with brown, finally adding fine black, wavy strokes with Indian ink to simulate the cracks of the original.

Ivory may be made plastic by dissolving its earthy salts with phosphoric acid; on the other hand, when brittle and friable from age, it may be toughened by boiling in gelatine.

There is little doubt it was at one time possible to soften ivory so as to allow of its being squeezed or moulded into sheets of considerable size. Unfortunately, this is a lost art, for none of the recipes which have been preserved have proved successful in the hands of modern chemists.

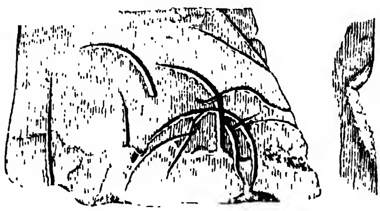
Ivory Substitutes. The curiously hard seeds of the *Phytelephas macrocarpa* are used as a substitute for ivory; the absence of the characteristic "engine-turned" figure of genuine ivory at once proclaims this substitute.

An artificial ivory known as bonzoline is supposed to be a mixture of celluloid and some very fine mineral earth.

The delicately fretted ivory fans made in Paris, and supposed to be of Eastern origin, are produced by drilling the design through a solid block of ivory and then sawing it into leaves.

Horn Carving. Ox and buffalo horns are chiefly used for this purpose, though rhinoceros horn is occasionally ornamented as a curio. Ram's horn is so decorated by Nature that further treatment is superfluous. Horns of deer are really deciduous bones, and with the exception of their being utilised as knife and cutlery handles, are generally better adapted as decorative objects when uncarved and arranged in pairs.

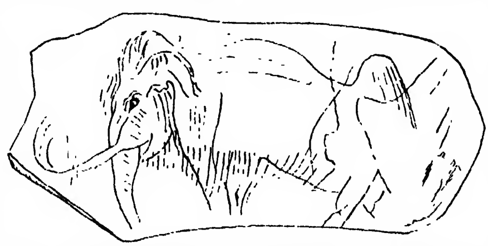
Horns may be carved with ordinary wood-carving tools, but owing to the smoothness, roundness, and natural greasiness of the surface it is not always an easy matter to get the tool to bite. Fortunately, horn can be softened by boiling. The carver therefore overcomes the difficulty by letting a jet of steam play on the horn, though he has to be careful not to allow it to remain subjected to a high moist heat for long at a time, lest the natural cement, which binds together the bundles of fibrous hairs of which it is constructed, should be decomposed.



59. RIB OF BALÆONOTUS SCORED WITH FLINT KNIFE

(A magnified section of a cut is shown to the right)

Working Difficulties. The carver also has to exercise considerable ingenuity in fixing his work firmly. Sometimes he will be able to keep it steady in a vice well padded with leather: at others by wedging it on both sides with wooden knees, and fixing cross-pieces above it. Or he may stand it upright and screw it to the bench, or fit the thin extremity into a block of wood or cement which can be held with a holdfast while the thick end is clamped to the table with a "long dog" [page 5810]. By this manœuvre a quarter-face can be worked at a time. There are no technical difficulties to be overcome in horn carving when once the outer skin has been pierced. A sharp knife is capable of doing most of the roughing out since the contour of a horn permits its use in almost any position.



60. CONTEMPORANEOUS PORTRAIT OF A MAMMOTH

(Carved on mammoth ivory)

An effective and permanent decoration is to stain the groundwork black with nitrate of silver, brown with chloride of gold, or yellow with nitric acid.

Horn may be made as plastic as putty by boiling it with quicklime, in which state it can be moulded into any desired shape, regaining its temper on being subjected to a continuous stream of cold water.

Shell Carving. The principal shell used for carving is that of the *Meleagrina margaritifera*, the Indian pearl mussel.

Mother-of-pearl, as it is called, is easily carved and turned, provided due allowance be made for its structural peculiarities. It consists of layer upon layer of a brittle, chalky material, packed closely together like the leaves of a book. If flaking is to be avoided, all cutting strokes must be made in directions radiating downwards and outwards from each high point of the relief. No special tools are required beyond sharp cutting scrapers of assorted sizes. Its brittleness handicaps the carver considerably, low relief and coarse fretting being the only decorations applicable.

Shells Displaced by Porcelain. Shell cameos, which were so fashionable for nearly 400 years, are now but rarely produced: indeed, the art of cutting them seems to have died out since Wedgwood imitated them so successfully in porcelain. The various and contrasted colours of the component layers of several species of shells suggested to the Italians of the Renaissance the possibility of substituting them for the stratified gems used for cameos. The shells most favoured for this purpose are given in the table

The deep layer is utilised as a background upon which to show up the design proper, wrought in the middle layer, the outer coloured portion serving to accentuate parts of the picture, and as a frame.

Cutting Cameos in Shell. Cutting shell cameos is tedious work, owing to the microscopic detail of the designs from which they are mostly copied. The finest bits and points are employed as the cameo reaches completion. Great care has to be exercised, not only in the first polishing, but also in subsequent cleansings, to avoid ruining the sharpness of the pattern, the chalky layer from which it is cut being very tender and friable.

SHELLS FOR CARVING

Name.	Colour of deep layer.	Colour of middle layer.
Bull-mouth (*Cassis rufa*) ..	Reddish or orange	Creamy white
Black-helmet (*C. tuberosa*) ..	Onyx brown ..	Pure white
Horned-helmet (*C. cornuta*)..	Brown or grey ..	Dead white
Queen's-comb (*Strombus gigas*)	Pink	Pinkish white

CARVING *concluded*

PROGRESS OF EUROPEAN STATES

Continued from page 6202

Russia—continued. Prussia and Frederick The Great. Italy from the Middle Ages to the Present Day. Spain and Holland

By JUSTIN McCARTHY

WE may resume the history of Russia with the death of Alexander I., in 1825, and the succession of Nicholas I., who was crowned at Moscow in 1826. For a time the history of Russia was mainly made up of wars against Persians or the remorseless crushing of Poland's efforts to win her freedom from Russian oppression, of futile alliances made with this or that European State for the purpose of strengthening Russia's power. The army was greatly increased by compulsory enlistment during this period, and there is the more satisfactory statement to be made that the general extension of the railway system in Russia was also a product of this reign.

The Crimean War. In 1853 began the Crimean War, in which England, France—then under the Empire of Napoleon III.—and Sardinia, at that time merely one of the States of a disunited Italy, made war on Russia in defence of Turkey. The war lasted until 1856, and its events and its conclusion are told in another place. While the war was still going on the Emperor of Russia issued a decree for the total emancipation of the serfs, 23,000,000 in number, throughout the whole Empire. This was put into force, and was carried to completion within two years.

The Emperor Nicholas I., who had begun his reign in 1825, was succeeded by Alexander II. in 1855. Russia's story for some time following was merely the struggle for something like political liberty and citizenship made by the great majority of the working population, and the efforts of the existing authorities now to conciliate by partial reforms and now to suppress by reckless force those ever-renewing efforts.

The knowledge of the development in political liberty which was going on through so many other parts of Europe was beginning to spread itself throughout Russia, and the people of Russia could not be prevented from making manifest their resolve to obtain something like political freedom.

The Czars and Russian Freedom. The effects of this contest between opposing orders and conflicting interests made itself evident in successive revolutionary conspiracies, and even in murderous outrages on the part of the unemancipated, and of ruthless punishments inflicted by the rulers. There appears to have been, on the part of more than one of the Russian czars, a sincere desire to render something like justice to the unemancipated classes, and to establish something like the representative principle of government throughout the Russian dominions. During the reign of Alexander II. some reforms were introduced, but they did not suffice to satisfy the demands of those for whom they were intended, and, indeed, they seem to have aroused only a fury of disappointed aspiration among the great masses of the Russian people.

One result was the foundation and the spread of the Nihilist conspiracy, the underlying principle of which seemed to be that everything was wrong in Russia and in most other lands, and that nothing but a total reconstruction of society could effect any lasting benefit for the world. Many of the Nihilists were sincere, but there were large numbers who had nothing in their mind but the destruction of all existing organisations, and who would have held back from nothing to gain their ends. In February, 1881, the Czar made known to his council a plan for the promulgation of a political constitution, but within a few days after this event he was killed by a bomb thrown at him in one of the public streets. He was succeeded by Alexander III., who was married to a daughter of the King of Denmark, sister of Queen Alexandra. He reigned from 1881 to 1894, and the work of Nihilism still continued. Many attempts were made upon his life by Nihilist conspirators, and it is believed that the shocks to his system of these repeated attempts led to the illness which caused his death.

The Hague Conference. Nicholas II., who succeeded him, and who was married to a granddaughter of Queen Victoria of England, made a marked advance in the constitutional policy approached by his predecessor. He showed himself distinctly in favour of a constitutional system from the beginning of his reign, made many concessions towards his Polish subjects, and proved himself an enlightened and conscientious advocate of the cause of peace among the States of the world. On August 28th, 1898, his government made known to the Courts of Europe his famous plan for the assembly of a conference of all Powers for the consideration of means to put an end to the incessant increase of armaments, and to occupy itself "with the grave problem of universal peace." This proposal led to the formation of the Hague Conference of 1898. That conference, however, proved disappointing in its results as the question of international disarmament was not actually brought forward; but the mere fact of such an arrangement having been proposed by Russia is in itself of great importance. The further consideration of the whole subject was not abandoned, but was postponed to a second sitting of the conference at the same place and for the same purpose.

Some time after this the Czar actually convened an assembly of the Duma, or national Parliament, a novel institution for Russia; but this first assembly did not appear to give full satisfaction to its author, and was suddenly and inauspiciously dissolved. Then

followed a number of outrages startling even for Russia, a series of murderous and fatal attacks on Ministers of State, governors of departments, and other public functionaries, followed by fierce and sanguinary efforts at repression. The Czar did not seem to lose hope or heart, and he soon announced that the convocation of a new Duma, with even more expanded representative power, was soon to take place. Meanwhile, however, the attention of all the world was drawn away from Russia's internal troubles by the outbreak of the war between Japan and Russia. There had been arrangements going on with regard to the rival claims of Japan and Russia concerning Manchuria and Corea, and the Japanese, at last becoming impatient of delays, declared war on February 6th, 1905.

The Coming Up of Japan. Then it became apparent to the whole world that a new Power was coming up in the East to shake the balance of controlling influences in the West. In the work of war the Japanese proved superior even to Russia with her vast military resources, and the Russians were compelled, after successive defeats, to make peace on Japan's terms, Japan only yielding so much of her original demands as was put in the form of a claim for money indemnity. Even this moderate concession created much popular indignation in Japan, where the public feeling, over-excited by continuous success, seemed disposed to insist that she should have abated nothing of her claims. The peace was brought about to some extent by the influence of President Roosevelt and the Government of the United States, who strongly urged upon Japan and Russia the world-wide importance of their coming to terms of settlement. The second Duma was summoned on March 5th, 1907, but the condition of Russia at the time of writing is anything but satisfactory.

PRUSSIA

Prussia as a separate State may be said to have had its beginning in 1511. The Margrave Albert of Anspach, of the family of Hohenzollern —a family of Frankish descent which had already become powerful in Prussia—and a kinsman of the King of Poland, was elected their Grand Master by the Knights. Prussia was not immediately freed from Polish rule, but in 1525 the Grand Master was acknowledged Duke of Prussia, and under his rule the country advanced in prosperity. He improved the existing laws and established schools, and during his reign the University of Königsberg was founded. Duke Albert became a Lutheran, as did many of his followers. His son was insane, and the Elector of Brandenburg, after being Regent, was, on the death of Duke Albert in 1618, made ruler of the Duchy. The House of Hohenzollern-Brandenburg have from that day been the rulers of Prussia. In the reign of his successor occurred the Thirty Years War by which the country was much disturbed, and the population and the finances of it diminished rapidly; but under his son Frederick William, known as the "Great Elector," Prussia attained a high position among European States and became prosperous in every way. Frederick increased the finances and established an army of 38,000 men. Under his successors, Frederick I. and Frederick William I., Prussia still advanced, and in 1701 became a kingdom. Frederick William is best known as the father of Frederick the Great, the most famous of all Prussian monarchs; he also did much for his kingdom, and by his rigid economy left the treasury in a flourishing condition and established a powerful army.

Frederick The Great. Frederick II. succeeded his father in 1740. He reigned for forty-six years, and under his rule Prussia became one of the great Powers of Europe. Frederick the Great was born in Berlin, January 24th, 1712. His mother was Sophia Dorothea, daughter of George I. of England. His early years were made so unhappy by his rigid military training and his education, which was equally rigid, that he tried, when only eighteen, to escape to England. His father was angry at this and would have sentenced his son to death but for the intervention of the Emperor. He did actually have Lieutenant Katte, whom he suspected of complicity, executed in his son's presence, and Frederick was imprisoned. The young Prince now saw that resistance was hopeless: he did everything in his power to conciliate his father, and in 1733 married the Princess Elizabeth Christina because his father wished it. He did not come to the throne for seven years after his marriage, and for those years he lived at Rheinsberg and gave much of his time to the study of music and literature, especially French literature. He also took great interest in the philosophical questions which were at that time much discussed by people of learning and culture, and he corresponded with Voltaire. But it is certain that he also gave much thought to the question of the expansion of his dominions—the Prussian Kingdom of which he was so soon to be the ruler, and whose territory he left twice the size it was at his accession.

The Seven Years War. One of his first acts, when he succeeded in 1740, was to make war on the Austrians, whom he defeated at the Battles of Mollwitz and Chotusitz in 1741 and 1742. He made an alliance for fifteen years with France, and this compelled Maria Theresa, whose accession in 1740 had separated Austria from Prussia, to cede to him Lower and Upper Silesia. By another war in 1744 he acquired still more territory, and after this there was a period of peace which lasted eleven years, and enabled Frederick to turn his attention to reforms in his dominions. In 1756 occurred the third Silesian war, better known as the Seven Years War. In this famous war, in which Frederick was the aggressor, he was in the end completely victorious, and showed himself to be a great military genius. The war ended with the Peace of Hubertsburg in 1763. In 1772 he shared in the first partition of Poland, of which he added a large part to the dominions of Prussia In 1778 he engaged in another war and acquired the Franconian Duchies. He also established the famous "Fürstenbund," or League of Princes. This was one of his last acts, for he died at Potsdam on August 17th, 1786.

ITALY

There is not much to tell of the history of Italy from the middle of the sixteenth to the end of the eighteenth centuries. By the Peace of Cambrai, in 1529, Charles V. of Austria became practically lord of Italy, and, thirty years later, his son Philip became, by the Peace of Cateau Cambresis, almost undisputed ruler. Venice alone remained really independent. Genoa, Lucca, and San Marino were independent in name only. Piedmont was given to Philip's cousin, the Duke of Savoy, who had regained Savoy and Nice. The Order of the Society of Jesus was founded in 1540, and the famous Council of Trent, established in 1545, defined the doctrines of the Church of Rome. Venice, formerly under the rule of her own Patriarch, now acknowledged the supremacy of the Pope of Rome.

But the days of Venice's greatness were over; much of the territory that had been hers was now in the power of the Turks, and notwithstanding the victory of the Battle of Lepanto, in which the Christians under Don John of Austria had defeated the Turks, Venice had been compelled to cede Cyprus to the Ottoman power. The conquest of the Peloponnesus in 1684 was the last triumph of the Venetians, and the Peloponnesus was recaptured by the Turks thirty years later. Other events of this period were two risings in Sicily and the revolt led by Masaniello in Naples—an event much celebrated both in poetry and romance. Masaniello was a Neapolitan who in 1647 organised a rebellion against Spanish rule for the remission of taxes. The rising was successful, but Masaniello was soon afterwards assassinated.

Italy Divided Among the Powers. The great days of Spain were also over, and after the war of the Spanish Succession, Italy was again divided among the European Powers. To the House of Savoy the Island of Sicily was given, with Victor Amadeus II. as King. He proved a good ruler, but in 1720 was compelled to give Sicily to Charles VI. of Austria in exchange for Sardinia, which remained under the rule of the House of Savoy until 1861. By the Treaty of Aix-la-Chapelle, Italy was once more broken up. The House of Savoy had Sardinia, Piedmont, and some other parts of Italy; the Austrians had Milan and Tuscany; Charles III., the Bourbon, was King of the two Sicilies, and his brother Philip was Duke of Parma. The Papal Territory included the centre of Italy as far as Venice, which remained a republic until 1797. Modena and Genoa were under the protection of France, and in 1755 Genoa gave the island of Corsica to that country.

For a time there was peace in Italy—peace, at least, from war—under the despotic sway of the Bourbons, who now held most of the peninsula. Of these rulers of Italy, Peter Leopold, Grand Duke of Tuscany, was far the most capable. He suppressed the Inquisition and made many improvements in the condition of his territory. In 1790 he became Emperor of Austria.

After the days of the Napoleonic wars and the fall of Napoleon, the national feeling of Italy began to concentrate itself more and more on the re-establishment of that Italian unity which had long been but a memory of the past. The practical working out of this purpose was mainly due to the efforts of Count Cavour, a great Italian statesman, Mazzini, a great and popular and patriotic agitator, and Garibaldi, a gallant, single-minded and brilliant soldier. Mazzini and Garibaldi were both Republicans by principle, and were strongly opposed to the system which divided Italy into a number of small kingdoms, and thus left the country under the influence of powerful rival sovereignties like France, Austria, and Russia.

Mazzini and Garibaldi. Cavour had risen high in public life in Sardinia when that kingdom had become a constitutional State, and his genius and influence had done much to draw the attention of Italy towards Sardinia as the Italian Power destined to take the leading place in the movement for Italian unity now making itself felt throughout the whole country. Both Mazzini and Garibaldi were willing to accept the rule of one constitutional sovereign, provided the country could, by means of that system become one united and independent Italy. Victor Emmanuel II. was then King of Sardinia, and his State was regarded by most of the Italian peoples as the rising hope of Italy's accession to national independence. Count Cavour became Prime Minister of Sardinia in 1852. The wars between France and Austria, under the rule of Louis Napoleon as Emperor, brought sudden support to the policy of Cavour.

Garibaldi headed an armed rising against the King of Naples, a kingdom still governed according to the most old-fashioned systems of tyrannical rule, and Victor Emmanuel, at the head of his army, supported the rising against the King, whose rule was detested by the vast majority of his subjects. On November 7th, 1860, the King of Sardinia entered Naples in triumph, and was welcomed as sovereign. On February 26th, 1861, the first Italian Parliament assembled, and Victor Emmanuel was declared King of Italy, and on March 31st, in the same year, the kingdom was recognised by Great Britain.

The capital of Italy was then transferred from Turin to Florence. Garibaldi made several attempts to capture Rome from the Papal dominion and make it the centre of the Italian power, but these attempts had to be resisted and suppressed by Victor Emmanuel, although he and his people were in thorough sympathy with the desire to make Rome the centre of united Italy, so far as political life was concerned.

Rome Ceded to Italian Rule. France had been occupying Rome for some time, but after the fall of the French Empire, in 1870, the French occupation of Rome came to an end, and on September 20th of the same year the King entered Rome and was proclaimed sovereign of United Italy, the political power of the Papacy thus coming to an end. King Victor Emmanuel died in January 1878, and was succeeded by his eldest son, King Humbert I., who was born in 1844, and from that time the kingdom of Italy has held its place among the States of

Europe. Pope Pius IX. died a month after King Victor Emmanuel and was succeeded by Leo XIII. King Humbert I. was assassinated on July 20th, 1900, at Monza, by Angelo Bressi, a Tuscan, and was succeeded by his son, Victor Emmanuel III., the present King. Pope Leo XIII., a great statesman as well as a great ecclesiastic, died in 1903, and Pope Pius X. was elected to the Papal Chair

SPAIN

The story of Spain, from the opening of the new era when the restoration of royalties had followed the fall of the Napoleonic Empire, is made up chiefly of dynastic and other internecine struggles. There were always rival family claims for the throne of Spain, which led to continuous domestic wars, and there were also continuous struggles among political parties and factions. There were arising in Spain great parties of men—in fact, large sections of the population—who were tired of the dynastic quarrels, who could not recognise any Divine right amongst the families who disputed for the crown, and were craving for some system of government more in accordance with modern ideas.

In 1817, the rule of despotism had again set in for Spain, but the representatives of despotism were in strife among themselves, and there was war, not so much between despotic power and liberty as between one Power claiming to be despotic and another which contended that itself, and it alone, had "the Divine right to govern wrong." In the meantime, the growing light of civilisation had guided some important reforms in the Spanish system, one of which was the abolition of the slave trade. Spain had some costly struggles brought upon her by her efforts to regain her power over Morocco. The war in which, unwisely and unfortunately for herself, Spain engaged with the United States, is described in another place. The sovereigns who ruled in Spain during the period now under our survey were Isabella II., Amadeo I., Alfonso XII., Maria Isabella, and Alfonso XIII., enthroned 17th May, 1902.

THE NETHERLANDS

The death of William the Silent, in 1584, was a great misfortune for Holland, for the country had been delivered by him from Spanish rule. The Union of Utrecht, in 1579, and the declaration of 1581, in which the Dutch renounced allegiance to Philip II. of Spain, had already made the Netherlands free. Maurice of Nassau carried on his father's work, and the Dutch won many victories at sea. Parma succeeded in taking Antwerp, but his fleet was prevented by the Dutch from joining the Spanish Armada in 1588. Parma died in 1592, and Philip II. in 1598, leaving the Netherlands unconquered: and, though Philip II. still called the Dutch "rebels," their successes at sea enabled them to make their own terms, and in 1609 he signed an armistice with them for twelve years.

Unfortunately, this time of peace was spent in religious and political struggles between the followers of Gomarus and the followers of Arminius, which ended in the defeat of the Arminians. Grotius and others had to fly, and Olden Barneweldt, the Grand Pensionary, was beheaded in 1618. But the Republic progressed all the same, and Frederick Henry, who succeeded his brother Maurice of Nassau in 1625, compelled Spain, by the Treaty of Munster, to recognise the independence of the Dutch Republic.

A Century of Prosperity. From this time Holland, for at least a century, progressed steadily in power and prosperity, and gave many great men to the world.

Holland had wars with England both in the time of Cromwell and during the reign of Charles II., and among the great admirals who commanded her fleets were De Ruyter, Tromp, Van Galen, and Evertsen. There were also wars with France in the reign of Louis XIV. in which Holland was defeated. De Witt, who had strengthened the navy, had neglected the army, and he became so unpopular in consequence that he was killed by a mob at the Hague in 1672. William of Orange, who became William III. of England, was chosen as Stadtholder by the people, and under him the country again became prosperous and successful. He married Mary, daughter of James, Duke of York, and was thus allied with England, and Louis XIV. had to sign the treaty of the Peace of Nimeguen in 1678. The Revocation of the Edict of Nantes drove many Huguenots to find a new home in Holland, and they helped the Dutch in their wars with France. After the death of William in 1702, Holland again became a Republic, and the Treaty of Utrecht in 1713 ended, for the time, the greatest epoch in her history.

The French in Belgium. In 1747 the Stadtholdership was re-established. In 1793 the National Convention made war on Holland, and French troops overran Belgium in the following year. The Patriots of the United Provinces, combining with the French, compelled William V. to fly to England. The "Batavian Republic" was succeeded, after many changes, by the reign of Louis Bonaparte; but this only lasted from 1806 to 1810. Holland then became part of the French Empire, but on the fall of Napoleon it again became a kingdom under the rule of the House of Orange. Belgium seceded from Holland in 1830, but nine years later the two countries made peace. Holland was ruled in succession by William I, II., and III., and during the reign of William III. some important changes were made in the laws. In 1862 the Bill for the Emancipation of Slaves was passed; in 1869 capital punishment was abolished, and in 1872 a new Treaty was made between Holland and England which defined and limited the sphere of influence and action of the two countries in the Indian Archipelago and removed some restrictions of a former treaty.

William had no son, and his daughter by his second marriage, Wilhelmina, the Princess of Orange, was chosen as his successor, Queen Emma being appointed Regent. William III died in 1890, and Princess Wilhelmina, who was then ten years old, became Queen of Holland.

Continued

COPPER AND ITS ALLOYS

Copper Ore and Its Treatment. Electrolytic Copper. Alloys of Copper. Brass and Bronze. Working of Brass and Bronze

Continued from page 6179

COPPER, the symbol of which is Cu, and the atomic weight 63·1, was one of the earliest metals discovered by man. The Copper Age followed the Stone Age, and preceded the Bronze Age. Copper weapons have been found in Egypt at a depth which, assuming the present rate of deposit as fairly constant since it was left there, gives its time of manufacture as not less than 10,000 years ago. The occurrence of large copper masses in the metallic state, the colour of which renders it easily recognisable, drew early attention to copper.

Physical Properties of Copper. The colour of copper is a characteristic red, with a tendency towards purple when cuprous oxide is present. It is only a little softer than nickel and iron, of the useful metals. Its tenacity and extensibility give it great industrial value; it can be rolled, beaten, and drawn into very fine leaf and wire. The specific gravity of the ordinary copper of commerce is from 8·2 to 8·5, rolled and hammered copper having a higher specific gravity than cast or crystalline copper. Electrolytic copper is 8·95. Roberts-Austen gives the specific gravity as 8·82. The precise melting point of copper has not been determined, but is between 1,050° and 1,100° C. Molten copper is of a sea-green colour, and of great fluidity. The thermal conductivity of copper is 736 (silver = 1,000) and the electrical conductivity 97·61 (Roberts-Austen) (silver = 100). Copper can be welded only with difficulty, and then only at a bright red heat.

Chemistry of Copper. Copper is unaffected by atmospheric exposure at ordinary temperatures, but under the influence of damp or of carbon dioxide it becomes coated with *verdigris*, an impure acetate of copper. When heated to redness in air it develops copper scale, a dark layer consisting of cupric oxide on top and cuprous oxide below.

Copper is immune from attack by water free from air, and by lime water, hence the value of copper for kettles and other utensils, for boilers and for boiler tubes. It dissolves easily in ordinary nitric acid and aqua regia, but only slowly in sulphuric and hydrochloric acids. It is remarkable, however, that the strongest nitric acid does not act on copper. Under an electric current copper may be separated from impurities and deposited on the cathode as pure copper, the application of this principle constituting the process of electrolytic copper refining, which we shall consider later on.

Sources of Copper. Within a half century the world's supply of copper has multiplied by ten, but the world's demands have grown quite as much as the supply, and the present high price of the metal is evidence that it is far from overtaking the demand. The main though not the only reason for this increase in consumption has been the growth of the electrical industries, with their huge demands upon the copper market. As the electrical industries grow and spread, so will the need for copper increase, so that there is no present likelihood of pause in an expanding consumption. The relative importance of the copper sources has undergone change during the last few decades. Formerly the world looked to Chili as the most important source of supply, but to-day the United States of America, with the enormous copper wealth of Montana and the Lake Superior district, supplies 60 per cent. of the world's copper requirements, with Spain a good second.

Copper Ores. Copper is found both in the native state and in combination. The largest deposits of native copper known are in the Lake Superior district of North America. New Mexico and South Australia also possess important deposits and the copper sand of Chili contains from 60 per cent. to 90 per cent. of metallic copper.

Copper pyrites, or *chalcopyrite* ($Cu_2S.Fe_2S_3$), known also as *yellow copper ore*, is the source of most of the copper supply of the world. It has a yellow colour with a black streak, a hardness of 3·5 to 4, and a density of 4·1 to 4·3. It is found at Rio Tinto, in Spain, and in every one of the five continents. Cornish ores, and the large deposits of Montana and Alabama, are of this variety.

Malachite ($CuCO_3.Cu(HO)_2$) is a beautiful streaked green copper ore which is much used for ornamental purposes. Its hardness is 3·5 to 4, and its density 3·7 to 4·1. It occurs in the Ural district of Russia, in Chili, and in Arizona and New Mexico. It contains, when pure, 57·33 per cent. of copper, but is seldom found pure, being usually associated with salts of lime and magnesia, oxides of iron and manganese and other substances.

Cuprite, or *red oxide of copper* (Cu_2O), is of a red colour with a red-brown streak, a hardness of 3·5 to 4, and a density of 5·7 to 6·0. It contains 88·8 per cent. of copper, and occurs in Montana in the upper sections of Butte City veins, in New Mexico, and in Russia.

Azurite ($2CuCO_3.Cu(HO)_2$) is of a beautiful blue colour with blue streaks, has a hardness of 3·5 to 4, and a density of 3·5 to 3·8. It is usually present with malachite, but in much smaller quantities. It carries 55·16 per cent. of copper.

Bornite, or *churesate* ($3Cu_2S.Fe_2S_3$), or *purple copper ore* (sometimes also called *peacock* ore) is of a brilliant purplish brown colour when uncovered, but exposure to the atmosphere speedily causes it to change, and it may become yellow or deep blue, green or purple. Its copper content varies from 40 per cent. to 70 per cent. Its hardness is about 3, and its density about 5. It is found in Montana, Cornwall, and Chili.

Chalcocite, or *copper glance* (Cu_2S), is of a streaked dark grey colour, has a hardness of 2·5 to 3, and a density of 4·8 to 5·8. It usually holds at least 55 per cent. of copper, and the deposits in Montana carry from 60 to 74 per cent. It is also found in quantities in Arizona, Colorado, and New Mexico, while smaller deposits are found in many other places

Treatment of Ores. The various ores of copper for metallurgical purposes may be classified into three groups. First there are the native copper ores, as found in the Lake Superior district, where the metal occurs in the form of metallic particles, and where the ore is concentrated mechanically, the resulting concentrate, or *mineral*, as it is termed, being melted down and toughened in refining

furnaces. Then the sulphide ores, the most important of which are copper pyrites, are subject to dry or wet processes, according to their nature and their copper contents. Dry methods are usually adopted with ores rich in copper and wet methods with poorer ores or with auriferous and argentiferous copper ores.

Chalcopyrite is a combination of copper with iron and sulphur, and the object in smelting is to separate the copper from these two and also, of course, to eliminate the gangue. The process depends upon the affinity of iron for oxygen and copper for sulphur. By calcination, or roasting the ores in heaps, or in shaft or reverberatory furnaces, they are freed from siliceous matter and concentrated, forming a copper *matte*, so-called. The matte is then smelted with a siliceous flux and oxide of copper is changed into a sulphide. Again it is fused with slag to oxidise the sulphide of iron and the result is a *white metal*, sometimes called *blue metal* or *fine metal*, with from 60 per cent. to 75 per cent. of copper. This is now melted in contact with air, and the oxide of copper formed reacts on the cuprous sulphide, forming an impure metallic copper (*blister* copper) and a slag rich in copper.

Copper Refining. The metal contains iron and other impurities, and has now to be refined. It is treated in a reverberatory furnace, and to remove the cuprous oxide poles of green wood are pushed into the bath, and charcoal or anthracite is sprinkled on the surface. When the metal has become pale and fibrous this refining is finished. The resulting copper ingot should show a flat surface. If it contain too much oxide it will be furrowed and is "underpoled," and if it be ridged on the surface it is "overpoled" and contains too little.

The modifications of this "reaction" process, as it is called, are numerous, and the varieties of furnaces and operations are very great. Each ore must be treated for its individual properties, and local conditions must also be considered. The "reduction" process is similar to the reaction process up to the "white metal" stage. The reduction process oxidises the sulphide completely, and reduces the mass by carbon. It is less economical than the other process.

The wet method of treating copper ore is followed for low grade ores. Copper sulphate is extracted from the roasted ore by bleaching with water, and the copper in solution is precipitated by the aid of another metal, usually iron, or by electrolysis. The great value of the wet process is that if the ore contain silver or gold these metals may be recovered.

Electrolytic Copper Refining. The electro-chemical treatment of copper ore has not yet been practised on a large scale, but electrolytic treatment of impure copper produces a copper of high purity, such as is required for electrical purposes. The principle of electrolytic refining of copper is simple. The electric current enters a bath of solution of sulphate of copper through an *anode* of impure copper and leaves it by a *cathode*. The action is that the anode is dissolved, but only the pure copper is deposited on the cathode, the remaining metals present as impurities, and also dissolved from the anode, not being so easily deposited as copper. We shall examine details of the process of electrolytic refining as practised in some of the largest works.

The first process in the electrolytic refining of copper is to melt the copper pigs or ingots so that they may be cast into the large flat plates which form the anodes in the electrolytic tanks. The charge of copper is melted in the *anode furnaces* as they are called, reverberatory furnaces used for this special purpose. Then the metal is worked by methods akin to those of puddling [see page 4635] for some hours, sometimes as many as thirteen or fourteen. This treatment dispels some of the impurities, and the copper is raised from usually 98·5 per cent. of purity to 99·5 of purity. Then the furnace is tapped, the metal is drawn off by the help of a ladle, and is poured into moulds which are mounted upon an endless chain. The copper plates which are to be used as anodes are 36 in. by 24 in. by 1 in. Each is made with two lugs on its upper edge, these being used to support the plate in the electrolytic tank. The plates are then put into frames holding 22 plates, the full charge for one electrolytic bath.

Electrolytic Bath. The tanks are filled with diluted sulphuric acid and sulphate of copper electrolyte, and are usually arranged in sets with a reservoir and pump to each set. They are arranged electrically in series, and the electrodes in each tank are parallel.

The thin cathode sheets used in the depositing tanks are themselves deposited in other tanks known as *stripping tanks*. The cathodes in the stripping tanks are pure rolled copper plates covered with grease or plumbago, upon the surface of which the new plates form, and from which they are afterwards easily detached. These new plates are beaten with wooden paddles and are hung by copper loops from copper rods which lie upon the edges of the depositing tank.

Now the electric current is passed through the bath, and the action is to transfer the copper of the anode plates to the cathode plates, upon which it is deposited. The charge is under treatment in the electrolyte for seven days, when the cathode plates have increased from 6 lb. to 8 lb. in weight to 75 lb. or 80 lb. Then they are removed and taken to the refining furnaces. The anodes, however, are not yet exhausted. New cathode plates are supplied and the process is resumed. The anodes last for six weeks.

The final process of refining is similar to that already described, when the green wood is plunged beneath the surface so as to remove the oxide by the carbon of the wood combining with the oxygen and escaping as carbon dioxide. The result of the process is a copper of 99·88 per cent. of purity.

Copper Castings. Casting copper so as to give good sound castings is not an easy matter, but it is a subject of some importance because several industries, particularly the electrical industry, are developing an increasing need for copper castings. The chief difficulties in casting copper are occasioned by impurities in the copper, by the formation of cuprous oxide while the metal is in a state of fusion, whereby blow-holes are caused, and by the great contraction during cooling, whereby the mould is not completely filled. The first-mentioned difficulty is overcome to some extent by the use of copper which has been electrolytically refined, and is therefore chemically pure. A common method of overcoming the cuprous oxide difficulty, in good practice, is by casting in chills or dry sand moulds, and by adding up to 5 per cent. of manganese at the time of casting. Manganese combines with the oxygen of the cuprous oxide, thus making the metal more uniform. Sometimes zinc or tin, up to $1\frac{1}{2}$ per cent., is added, and has the desired effect. For very thin or very sharp copper castings, the introduction of one-half of 1 per cent. of phosphorus has beneficial effects. It has a deoxidising effect, and increases the fluidity.

Copper Oxides. Numerous compounds of copper have a place in industry. We cannot go into great detail in every one of them, but we can pass them under cursory review and indicate their value and importance.

Cuprous oxide (Cu_2O), otherwise known as *red oxide of copper, copper suboxide,* and *copper hemioxide,* is found in the native state as cuprite or red copper ore [see page 6305], and as chalcotrichite. It may be prepared by heating finely divided copper in air below red heat and in several other ways. It is used as a pigment, and, in combination with black oxide of copper, constitutes one of the copper antifouling paints used for ship bottoms. It is also used in the manufacture of ruby glass.

Black oxide of copper (CuO), or copper monoxide, is found as *melaconite* or *black* copper in native deposits, prominently in the Lake Superior district. It is used in organic analysis. It is also used in the manufacture of green and blue glass [see page 4533].

Hydrated copper oxide ($CuO \cdot H_2O$) is used in paper staining. It is of a blue colour, but develops into green under atmospheric exposure. Schweitzer's reagent, which is used in the manufacture of Willesden paper, is a solution of cupric hydrate in strong ammonia. Treated with this solution cellulose gelatinises and is completely solved. When the solution has been evaporated, a gummy mass consisting of cellulose and copper oxide remains. In making Willesden paper the solution is allowed to dry on the paper, making it water resisting and binding the constituent fibres together, thereby increasing the strength. Ropes and netting are also treated by the same process. Thorpe quotes the alleged best method of preparing hydrated copper oxide: "Six parts of copper sulphate are dissolved in water and mixed with a solution of three parts of calcium chloride. The clear liquid is decanted from the precipitated calcium sulphate and is mixed with one and a half parts of lime, made into a cream with water. The greenish precipitate is collected, washed and mixed with one-fourth of its weight of slaked lime and as much pearlash, and to render the colour more permanent one-fourth of its weight of ammonium chloride and one-half of its weight of copper sulphate are usually added."

Chloride and Other Copper Salts. The *Brunswick green* of commerce is *cuprous chloride* (Cu_2Cl_2). It has a wide use as a pigment. It is found native as *atacamite.* It is prepared from copper turnings by moistening them with hydrochloric acid or ammonium chloride under atmospheric exposure, or it may be made by boiling copper sulphate in solution with a small percentage of bleaching powder solution.

Cupric chloride ($CuCl_2$) is used for methyl violet in calico printing and for oxidising cutch colours. It is made by heating copper in excess of chlorine or by dissolving oxide of copper in hydrochloric acid.

Sulphate of copper ($CuSo_4 \cdot 5H_2O$), or *blue vitriol,* as it is popularly known, is the most important salt of the copper. It has many uses. In agriculture it is used for dressing wheat and other seeds. The practice is to soak the seeds in a weak solution of the salt within twenty-four hours of being sown. It is also applied to vines, usually as a solution of from 10 per cent. to 20 per cent. It is also applied to timber, and prevents rot. Sulphate of copper is also used in cotton printing, chiefly with potassium bichromate or iron mordants, and with logwood for black dyeing.

It is made from metallic copper, usually scrap copper, which is heated in a reverberatory furnace, sulphur being afterwards added and the doors shut. After some time the doors are opened and the heat is increased so as to oxidise the sulphide with sulphate. The hot mass is withdrawn, immersed in sulphuric acid (diluted), and, after settling, is decanted, concentrated and crystallised.

Cupric sulphide (CuS) is also used in calico printing for fixing aniline black. It is made in one way by precipitating a sulphate solution with sodium sulphide.

Nitrate of copper ($Cu(NO_3)_2$) has a limited use in cotton printing and textile dyeing. It is made by dissolving metallic copper or the carbonate or oxide in nitric acid.

Verdigris and Other Pigments. *Acetate of copper* is used as a pigment and in indigo dyeing as an oxidising agent. *Verdigris,* erroneously referred to by many authorities as a carbonate of copper, is a mixture of basic copper acetates, the monobasic, dibasic and tribasic acetates being present in different proportions in different varieties of verdigris. The varieties of verdigris are used for oil and water colour paints, for the manufacture of emerald green and other copper paints, and in dyeing and calico printing. Green verdigris is manufactured commercially by placing copper sheets for some weeks between cloths moistened from time to time with pyroligneous acid or acetic acid. The verdigris forms as green crystals. Blue verdigris is made by allowing the refuse of the wine press—consisting principally of grape skins—to ferment, and by placing into this thin copper sheets. The copper sheets become coated with verdigris. They are allowed to remain in the mixture for about two to three weeks, and are afterwards left to stand and subjected to occasional moistening with water or wine during some two months. The verdigris is removed and squeezed into cakes.

Emerald green, referred to above and known also as *imperial green* and *Schweinfurth green,* is an *aceto-arsenate of copper.* It is a brilliant green of pleasing shade and is largely used. Wallpaper stained with this green is found to give off a peculiar odour when the wall is damp, and this is alleged to be poisonous. This pigment is manufactured by mixing boiling concentrated solutions of copper acetate and arsenious oxide. The volume is doubled by the addition of cold water, and the mixture is placed in bottles or flasks filled to the top so that premature crystallisation may not occur. Crystallisation takes place gradually, and is not complete for a few days. There are other methods of making the pigment, but that described yields the finest product.

Scheele's green is arsenite of copper. It was formerly in extended use but is now of little importance. It is made by adding arsenious oxide to a boiling aqueous solution of potassium carbonate; after filtering, this is added to an aqueous solution of copper sulphate and the arsenite of copper is precipitated.

Some basic *carbonates of copper* are known commercially as *verditer* green or blue and *Bremen* green or blue. They are used chiefly for paper staining. *Malachite* is a basic carbonate. Verditer is made commercially by grinding sea salt and blue vitriol with water and digesting the resulting paste in wooden boxes along with pieces of copper plates. When the chemical action is complete, hydrochloric acid is added with agitation. Caustic soda and water follow as an addition to the mixture, and the product is washed, filtered and dried.

Alloys of Copper. The most valuable of the alloys of copper are those with tin and zinc, the tin-copper alloys forming the important family of the *bronzes*, and the zinc-copper alloys giving us *brass*, both of which we shall consider at some length. With gold and silver, aluminium, nickel, and antimony, copper also alloys well [see pages 5856, 5983 and 5992], but with lead and iron it is unsatisfactory.

Successful alloys of copper depend greatly upon the absence of deleterious ingredients in the copper used. Cuprous oxide makes the metal red-short and cold-short, and the higher the proportion of cuprous oxide the more pronounced are these faults. It also causes castings of the metal with which it may be mixed to contract considerably. Sulphur in copper makes blown castings; silicon affects the ductility, pales the colour, and gives brittleness; nickel and antimony, singly or in combination, decrease the malleability; phosphorus increases the hardness and the fusibility.

Copper Alloyed with Gold and Silver. The British gold coinage is an alloy of gold and copper [see page 5851]. The colour of a gold-copper alloy shades into red, and green gold is an alloy of gold, silver, and copper. Silver-copper alloys are hard, strong, and tough, and give out a clear, penetrating sound when struck. Copper may be added to silver up to almost 50 per cent. of the alloy without changing the colour of the silver. Care must be taken in casting a silver-copper alloy, or "liquation"—that is, separation, may take place. In working articles of silver-copper, the frequent annealing necessary causes the copper to oxidise, giving the alloy a steel-grey colour. This colour is removed by the process of "blanching," so-called—that is, boiling the articles in dilute sulphuric acid (1 in 40). This process dissolves the surface copper and gives a surface of pure silver.

Bronze. Bronze is an alloy of copper and tin. It has been in use from prehistoric times, and in the early days it was more nearly a pure binary alloy than it became during the mediæval ages, when its value was usually impaired by a percentage of lead. Although tin is a soft metal by itself, it forms a very hard metal when alloyed with copper. If bronze is to be rolled into sheets, the percentage of tin must be small—not more than from 4 per cent. to 6 per cent.

Most of the bronze of commerce is not a mixture of pure copper and tin, especially when it is made with an admixture of old bronze, which usually contains other metals as impurities.

A small quantity of zinc in the alloy makes bronze castings sharp and tends to prevent blow-holes, but the zinc should not constitute more than 2 per cent. of the whole, or the appearance will tend towards that of brass. Lead in bronze is detrimental, especially when the alloy is to be cast; it increases the liability to oxidation, and as the lead tends to liquate from the bronze, the castings are unequal. Iron hardens bronze and gives a whitish colour; it is often introduced when the bronze is to be used for axle bearings. Nickel makes bronze harder, and decreases the toughness.

Properties of Bronze. The colour of bronze may be varied within wide limits by the different proportions of the constituent metals. Bronze with over 90 per cent. of copper is of a pure red colour. As the copper decreases, the colour passes through orange yellow to pure yellow at 85 per cent. of copper. A copper proportion between 50 per cent. and 35 per cent. gives a pure white bronze, and below this proportion the colour is steel grey, but as the copper becomes very low, the white colour reappears.

Tin reduces the ductility of bronze very much, and as low a percentage as 15 makes it impossible to hammer the alloy without fracture, even when it is hot. The maximum hardness of pure bronze is when it is made of 72·8 per cent. of copper and 27·2 per cent. of tin. As the tin increases above this proportion, the hardness diminishes, until, when the tin is two-thirds of the whole, the alloy is as soft as pure copper. Bronze, very rich in copper, is made very hard and very brittle by repeated forging. Cooling red-hot bronze rapidly makes it much less brittle and less dense, so that bronze bells rapidly cooled are deepened in tone. The higher the proportion of copper in bronze the higher is the point of fusion. Thus, bronze with 95 per cent. of copper melts at 2,520° F., while, when the copper is only 80 per cent., the melting point is only 1,868° F.

Bronze for Various Purposes. The general rules which should guide in the manufacture of bronze for various purposes have been given, but we may tabulate common formulæ of bronzes for various industrial purposes:

COMPOSITION OF BRONZES

Purpose.	Copper.	Tin.	Zinc.	Lead
Rail waggon axles	75	20	2	
Piston rings	84	2·9	8·3	4·3
Stamped articles	64	5·5	30·5	
Small castings	94	6·0		
Cocks..	88	10	2	
Steam whistles	80	17	2	
Articles to be hard soldered ..	87	12	1 part antimony.	
To resist atmospheric action ..	93	7		
Speculum for telescopes	66·6	33·3		
Very tough	32	3	1	
Valves and fittings (Admiralty mixture)	90	10	2·5	
Soft gun metal	16	1		
Gun metal for casting	9	1		
Maximum hardness for bearing metal	5	1		
Bell metal..	4	1		
Ordnance metal	91·6	8·3		

For bronze statuary, the composition of the alloy depends upon the colour desired. The following proportions are recommended by Brannt to give the shades indicated:

COMPOSITION OF STATUE BRONZES

	Percentages.		
	Copper.	Tin.	Zinc
Red yellow	84·42	4·30	11·2
Orange-red	83·05	3·92	13·0
Orange yellow	81	4	15
Pale orange	73	4	23
Pale yellow	70	3	27

Another authority states that the best statue bronze has the following composition: copper, 78·5 per cent.; tin, 2·9 per cent.; zinc, 17·2 per cent.; and lead, 1·4 per cent. If the proportion of zinc be too high in a statue bronze, the object loses the warm colour desired in statues, and when the zinc is too high the natural green tone, termed *genuine patina*, which a statue of the proper composition gains from exposure to the air, is not acquired, but one shading into black.

In making alloys into which tin enters, it is usual to put in one-half of 1 per cent. more tin than the final alloy is desired to carry, this quantity being lost by oxidation during the period of fusion.

Bell Metal. Bell metal is a variety of bronze, as it is essentially a copper-tin alloy. Occasionally, other metals are introduced in order to modify the tone. Common cheap bells are frequently made of brass or of steel. The low-priced bicycle bells are of this order, but gongs and house bells, clock bells, and sleigh bells, tower and church bells, are made from the bronze alloy known for centuries as bell metal. We refer under Manganese Bronze [see below] to claims for that alloy as a material for bells. It was formerly considered that a small percentage of silver improved the tone of a bell, but this view is no longer held, and the use of silver in bells is now discarded. The usual bell metal contains about 20 per cent. to 25 per cent. of tin. The following table gives the recognised formulæ for some bell metals.

COMPOSITION OF BELL METALS

	Copper.	Tin.	Zinc.	Silver.	Lead.	Bismuth
House bells	80	20				
Do. smaller ..	75	25				
Small hand bells ..	40	60				
French clock bells ..	72	26·56		1·44		
German do.	73	24·3	2·7			
Swiss do.	74·5	25			0·5	
Sleigh bells	84·5	15·4				
Gongs	82	18				
White table bells ..	17	80				3

A good bell metal is grey white in colour. In practice, the fracture determines the quality of the metal for the bell founder. If too coarse, the alloy must be made richer in tin; and if too fine, the tin is already too high, and copper must be added. Bells made from metals that have been frequently melted are not pure toned, this being caused by the oxide solution which has come into the alloy. But the art of the bell-founder embraces more than merely making a suitable alloy. The size, shape, and diameter of a bell, and the relation of its height to its diameter, have much to do with the sound that it gives out. Small bells are often cast in iron moulds, but large ones are always cast in the sand.

Phosphor Bronze. *Phosphor bronze* possesses very great strength, and can be rolled and hammered in a cold state. The name would indicate that it is a bronze carrying a certain percentage of phosphorus, but it is not always so. A more appropriate name would be *deoxidised bronze.* Phosphorus is used in the preparation of bronze, although the final metal may contain no phosphorus. Copper usually contains cuprous oxide in solution, and this oxide reduces the strength of any alloy made from copper containing it. By the introduction of phosphorus when the alloy is in a state of fusion, a complete reduction of the cuprous oxide is effected. The quantity of phosphorus can be gauged accurately in accordance with the cuprous oxide present in the metal. No phosphorus may remain in the alloy. A practice in making phosphor bronze is to introduce the phosphorus as phosphor copper or phosphor tin, or sometimes as both, these alloys having been prepared beforehand. To make phosphor copper heat four parts of superphosphate of lime, two parts of granulated copper, and one part of finely powdered coal in a crucible. Phosphor copper with 14 per cent. of copper will separate at the bottom of the crucible. Phosphor tin may be made by heating together three parts of anhydrous phosphoric acid, one part of carbon, and six parts of tin. Then, to make the phosphor bronze, 10 ounces to 12 ounces of this phosphor bronze or phosphor tin is added to each cwt. of molten bronze. The field of phosphor bronze is in articles such as hydraulic presses and propeller blades, where great strength is required. Sometimes lead or aluminium is introduced into phosphor bronze for specific purposes.

Silicon Bronze. *Silicon bronze,* which is an alloy of copper, tin, and silicon, or of copper and silicon only, has very high tensile strength, and has been much used for telegraph and telephone wires. Such wires have been erected with stretches of 1,000 ft. with no intermediate supports. Phosphor bronze has, however, largely taken its place. A formula recommended for silicon bronze specifies copper 97·12 per cent., tin 1·14 per cent., zinc 1·10; and silicon 0·05 per cent. The tensile strength of this alloy is said to be 600 lb. for 0·001 square inch section. Silicon bronze owes its properties to the fact that silicon, while reducing the cuprous oxide in the copper just as phosphorus does, seems to have a greater affinity for the copper than phosphorus has.

Manganese Bronze. *Manganese bronze* is, properly, not a bronze at all, but a brass; yet, on account of its name, we refer to it here. The following mixture is frequently used: copper 51 per cent., manganese copper (containing 20 per cent. of manganese and 8 per cent. of zinc) 40 per cent., and aluminium 1 per cent. The manganese copper, besides containing manganese, usually contains from 2 per cent. to 4 per cent. of iron. Manganese bronze possesses very high tensile strength. The alloy of the composition given above has a tensile strength of 36 tons per square inch and an elongation of 20 per cent. A higher percentage of zinc increases the hardness and tensile strength and diminishes the elongation, while a lower percentage has the opposite effect. The sphere of manganese bronze is in the manufacture of ordnance, propellers, pinions, and bearings, where its qualities make it desirable. As the tin constituent in the true bronze alloys is replaced by the cheaper zinc in manganese bronze, it is cheaper than the other special bronzes without showing inferior qualities as a special metal.

Manganese bronze finds some use as a bell metal instead of the usual copper and tin alloy generally used for the purpose. The advantages claimed by the advocates of manganese bronze for this purpose are that in comparison with the older composition it is more sonorous, has a mellower tone, and is not liable to be cracked. The usual bell metal is made very hard and brittle in order to improve the quality of the tone.

Aluminium Bronze. *Aluminium bronze* is an alloy of copper and aluminium, and contains no tin, hence the use of the word bronze is not quite accurate, although it has come to be accepted. The content in aluminium is never usefully higher than 10 per cent., but even up to this modest proportion colour and physical properties vary a good deal. With 5 per cent. of aluminium the colour is golden, at 7½ per cent. it partakes of a green-gold hue, and at 10 per cent. it is a bright golden colour. These alloys have great tensile strength, are exceedingly malleable in both the hot and the cold states, give sharp, clean castings, and admit a fine polish. The highest qualities of aluminium bronze are brought out by remelting it three or four times, and its strength may be further increased by hammering so that it may be made equal to steel. In casting aluminium bronze experience is necessary to good work. Its shrinkage is about twice as much as that of brass [see also page 5992].

Aluminium Brass. *Aluminium brass* is properly so termed, being an alloy of copper, zinc, and aluminium. Here also the percentage of aluminium is invariably low: if it be higher than 15 per cent. the alloy becomes red short and hard. An alloy containing 60 parts of copper, 30 parts of zinc, and 2 parts of aluminium can be worked mechanically by rolling, stamping, or forging, and has a valuable use for cartridge shells, because the aluminium imparts the property of resisting corrosion by the gases of the powder. It has been claimed that aluminium brass with from 1 per cent. to 3 per cent. of aluminium has much similar properties to aluminium bronze with from 5 per cent. to 10 per cent. of aluminium, and, of course, it is much the cheaper; but we question the evidence for this claim. Certainly aluminium brass is heavier and oxidises more easily. But the aluminium and zinc seem to form an intimate combination, and to develop properties even superior to the aluminium-copper alloys. The field for aluminium brass is in machinery parts and fittings in which exceptional strength is desired, such as valve seats, hydraulic and mining machinery, and propellers.

Bronze Powders. Most of the bronze powders used to coat metal, paper, wood, and other materials are made in Austria. A large number of different shades are procurable. Zinc and not tin is alloyed with copper to form the material from which they are made, so that the term *bronze* is technically incorrect. Powders which incline to white in colour have a high zinc content, and those that incline to red are high in copper.

Brannt gives the following compositions for some representative colours:

ALLOYS FOR BRONZE POWDERS

Colour.	Copper.	Zinc.	Iron.
Yellow	82·33	16·69	0·16
Pale green	84·32	15·02	0·63
Lemon	84·50	15·30	0·07
Copper red	99·90		
Orange	98·93	0·73	
Pale yellow	90·00	9·60	
Crimson	98·22	0·50	0·56

All the variety of shades are not, however, obtained by varying the composition of the alloy so much as by heating the alloy (after it has been finely pulverised), until a layer of oxide of the desired shade surrounds each individual particle.

In making the bronze powders the alloy is beaten into fine leaves by power hammers. These leaves are then forced through a fine sieve with the assistance of a scratch brush, oil being added at the same time, and the oil and powder passes through a grinding machine, which consists of one steel plate mounted with fine needles having blunt points revolving against another steel plate. The metal is here reduced to a very fine powder, and the oil is removed, first by putting the mass into water, where the oil floats off, and then by pressure.

Brass. Although the alloys of copper and tin—the bronzes—can claim antiquity, the alloys of copper and zinc, generally known as *brass*, can claim a much wider use industrially. Brass is properly a binary alloy, and should contain only copper and zinc; but pure brass is seldom made. The alloy is usually associated with tin, iron, lead and arsenic, those metals sometimes being present as impurities in one or both of the constituent metals, and sometimes again being added so as to modify the properties of the alloy. The two metals, copper and zinc, alloy within very wide limits. The higher the percentage of copper the more does the colour of the alloy tend towards gold, and copper also increases the softness and the malleability. As the proportion of zinc increases the colour becomes paler until it is a pale grey, and zinc increases the brittleness, hardness, and fusibility. A proportion of zinc up to 7 per cent. does not change the colour of the copper to an appreciable extent, but when the proportion comes above this quantity the tone is red-yellow. Then at 14 per cent. the colour has modified into pure yellow, and above 16 per cent. it goes into a mixed yellow, while at over 30 per cent. the red colour returns, and is at about its maximum when the two metals are present in equal proportion. As the zinc exceeds 50 per cent. the colour rapidly pales, passing through reddish white at 53 per cent., yellowish white at 56 per cent., bluish white at 64 per cent., and into lead colour as the zinc exceeds this limit.

Colours of Brass. The various phases through which the colour of brass passes as the proportions of the constituent metals vary may be given in the form of a table.

COLOURS OF BRASS

	Composition.	
	Copper. Per cent.	Zinc Per cent
Red	95	5
Reddish brown	90	10
Red-yellow	85	15
Reddish yellow	80	20
Light yellow	75	25
Yellow	70	30
Dark yellow	65	35
Reddish yellow	60	40
Golden yellow	50	50
Light grey .	40	60
Lead grey .. .	30	70
Darker lead grey	20	80
	10	90

The physical properties of brass, other than colour, are also much influenced by the proportions of the metals alloyed. A small proportion of zinc increases the fusibility without affecting the hardness; a high proportion increases the malleability when cold, but makes forging when hot impossible. Lead causes brittleness if it be present in brass in large quantities, but small quantities increase the ductility, making it better for turning and filing. A small proportion of phosphorus makes sounder brass castings, by increasing the fluidity and tenacity, and helps the alloy to resist atmospheric action. It also permits of tempering to some extent. The composition of commercial brass for many specific purposes is given in the following table [see also table of bronzes on page 6308].

COMPOSITION OF BRASS

Purpose.	Copper.	Zinc.	Tin.	Lead
Gas fittings	40	20	..	1
Sheet brass for stamping and turning	3	1		
Brass wire	67	33		
Soft brass for hammering ..	7	3		
Tough brass for engine work	100	15	15	
Brass for soldering..	8	3		
Sheathing brass	3	2		
Nails for sheathing	87	4	9	
Yellow brass	2	1		
White brass	10	80	10	
Red brass	16	2		
Brass for forging hot	33	25		
Pinchbeck	88	12		
Tombac	86	14		

The common quality of brass used in the foundry is termed in the trade *ash metal.* This is a general mixture suitable for cheap work, and is very wide in its quality. It is made by melting together scrap brass, borings and filings, sweepings and skimmings. These materials are riddled so as to free them from unnecessary dirt, and are washed, melted, and poured into ingots so as to be ready for use. Remelting improves brass, although there is loss of weight in any remelting, so that to remelt brass is more expensive than the mere cost of fuel and labour which it entails.

Standard yellow brass, so called, is an alloy containing two parts of copper to one part of brass. It is common to use this mixture already made as an ingredient in brass mixtures for casting, particularly for *red metal,* as it is called. A cheap red metal is made by alloying 36 parts of yellow brass (standard) with 46 parts of copper, 14 parts of lead, and 4 parts of tin. For highly polished red metal plumbers' fittings a common formula is 4 parts yellow brass, 16 parts copper, and one part each of lead and tin. For red metal to stand riveting the proportions of lead and of yellow brass are usually increased and the proportion of tin lowered. Thus, a good formula frequently followed takes 26 parts of yellow brass, 66 parts of copper, 5 parts of lead, and 3 parts of tin.

Brazing Metal. For the coppersmith the most commonly used alloy of copper is called *brazing metal.* Whatever may be the composition of the brazing metal—and this depends upon its purpose—it is always desired to retain to a great extent the malleability, fusibility, and colour of copper. If the zinc be higher than 20 per cent. of the alloy the red colour of copper is replaced by the yellow colour of brass. The chief use of brazing metal is in the manufacture of tubes [see page 5325]. Brazing metal may be made from copper and zinc only, but very small additions of lead and tin make the alloy more easily worked in the sheet. A common mixture is eight parts of copper to from one to two parts of zinc. The best qualities have only 6 per cent. of zinc. Sometimes 2 per cent. of aluminium is incorporated, and is, indeed, specified in some Government work, but although tubes made to this formula give a more rigid joint than ordinary brazing metal, the aluminium makes the alloy less easy to work. A special article on engineers' coppersmithing appears on page 3884 and the following pages.

German Silver. German silver is brass with a proportion of nickel, the amount of which ranges from 15 per cent. to 25 per cent. according to the quality of the alloy. A formula frequently used prescribes three parts of copper to one part each of zinc and nickel. German silver ought to be of silver whiteness and almost untarnishable if made from pure metals, but the presence of impurities such as arsenic and antimony in the constituent metals detracts from this result. A small proportion of tin—up to 3 per cent.—permits German silver to take on a high polish; lead or manganese in a similar proportion increases the fluidity and gives good castings, while iron increases the hardness and helps the whiteness. The usual method of making German silver is to make an alloy of nickel and copper, and another alloy of nickel and zinc, the latter being added to the former while both are in the molten state [see also page 5983].

Copper Amalgam. Copper amalgam is an alloy of copper and mercury; it has a wide field of industrial use. Its chief sphere is in the recovery of gold from the crushed quartz by the use of amalgamated copper plates [see page 5847]. The alloy is not obtained by the direct method—that is, by uniting the fused metals. There are several methods of preparing copper amalgam, and we may notice one of them. Zinc strips are immersed in a sulphate of copper solution and shaken vigorously. The copper, which deposits as a fine powder, is washed and triturated with a solution of nitrate of mercury. Hot water is poured on the copper, and mercury (seven parts to three of the zinc) is added. The mass is kneaded into combination, and a longer kneading makes it more intimate. Then the water is discarded, and the paste remaining can be shaped to any desired form. Copper amalgam has the curious property of becoming soft when placed in boiling water. It is also used to a limited extent in cementing metals together. The metals to be joined must be heated to just under 200° F., after which the amalgam, usually in the shape of wire, is applied and the parts pressed together.

Manufacture of Brass. The earliest method of manufacturing brass was to fuse copper with zinc-bearing ores, usually calamine [see page 6166]. The results of this method were by no means uniform, owing to the varying properties of the ores used, even with ores from the same bed. Thus, as with all rule-of-thumb methods, the men who practised this method had to be expert in their judgment, able to tell by colour and fracture that the desired point in alloying had been reached. This method has not yet quite disappeared, but it has almost done so, and its death knell has long sounded in the best modern practice.

The present day practice of the brass-founder is to heat the metals in crucibles placed in furnaces. Many attempts have been made to dispense with the need for crucibles in brass making, but all attempts to fuse the metals direct in special furnaces have been unsatisfactory and have resulted in a return to the crucible. The types of furnace vary with the kind of fuel used, and with the size and regularity of the output. We may consider a furnace of small size heated with coke, and taking one crucible, capable of making about 80 lb. of brass. The furnace is about 28 in. deep with a horizontal section about 15 in. square. The chimney must be not less than 15 ft. high, and is usually 10 in. square, the flue connecting it with the furnace being, say, 7 in. by 10 in. The crucible rests on a firebrick placed on the firebars. It is heated, usually, by being placed upside down in the furnace. Then it is placed upright and packed around outside with coke. The copper and zinc have meantime been weighed in their proper proportions, but not mixed. The copper, in small pieces, is placed in the hot crucible and melted. Then the zinc, or spelter, broken into small pieces and warmed, is added gradually and stirred. Zinc volatilises, so that the proportion of zinc in the final alloy is never so high as it was in the weighed metal. Every time brass is remelted the zinc content becomes less. The brassmaker allows for this loss by using more zinc, in a definite proportion, than he wishes the alloy to show. As the metals fuse, the surface is sprinkled with powdered charcoal, borax, or broken glass, so as to prevent oxidation. After all the zinc has been melted the crucible is covered over for a few minutes before being poured. If part of the charge is old brass, this is melted first, then the copper is added, and when the latter is fused the zinc is put in as already described.

Brass Furnaces. There are many so-called improved furnaces, each with specific claims to merit, offered for the use of brass founders, but the

common furnace has too strong a hold to be easily displaced. Tendencies during recent years have been towards liquid fuel instead of hard coke, and the value of many patent furnaces offered has consisted in their ability to utilise cheap oils as fuel. Gas is also used for brass melting, and may be the most economical fuel with a very small plant and where the work is intermittent.

Patterns for Brass Castings. Patterns have been discussed at some length in previous articles [see pages 2337 and 2453], and the general remarks and instructions there given apply to brass. The small size of most brass castings causes the use of metal patterns to a far greater extent than for iron castings. Metal patterns, generally, give cleaner castings than wood patterns, and brass castings often carry some finely-cut ornamentation for which wood would be unsuitable as a material upon which to work. Metal patterns for brasswork are usually made of brass, primarily because it is more convenient to make them of brass in a brass foundry, and also because brass patterns require no preliminary preparation such as rusting and varnishing as iron patterns do, an application of a black-lead brush being all the treatment required.

Moulds for Casting Brass. The condition of the sand is of great importance in brass casting. If the moulds are made of loam they must be thoroughly dried before use. Good moulding sand is better than loam, however. If the sand is too meagre it will give a rough surface, occasioning labour and expense in finishing. The addition of a little flour paste to the sand will obviate this trouble, and if the sand be too "fat," the addition of powdered charcoal will prevent bad effects. The pouring temperature must be carefully gauged. If the metal is not hot enough, sharp castings cannot be secured; and if it is too hot, porous castings will result, and there will be loss of zinc by oxidation. Casting from the bottom is desirable as thereby the air cannot rise through the casting and cause blow-holes.

Brass - founding. In brass-founding, the ordinary iron-founding practice is followed [see page 2862], but there are a few points where variation is required. The contraction of brass in cooling is greater than that of iron, therefore the patterns have to bear a different relation to the work. Small castings of brass—say, under 12 in. long—shrink $\frac{1}{8}$ in. in each foot, and over this size the contraction is $\frac{3}{16}$ in. Brass sets more quickly than iron, therefore the molten metal must reach home more quickly, and to secure this the gates and runners are usually made larger. The sand used for brass is generally more porous than it is for iron, and there is not so much venting. Much brass work is poured through the ends of the mould boxes instead of by the top, the boxes in the end pouring being made to be at an angle in a trough, the object being that spilt metal may be recovered from the trough instead of being lost in the sand. Vertical pouring, which is common with iron castings, is infrequent with brass, there being less risk of scabbing and of blow-holes in the latter case.

Casting Bronze on to Iron. Sometimes it is desirable that a piece of mechanism should be of iron or steel inside and of brass or bronze outside. We may take as a typical instance of such work the pump plunger, which may be wanted with an iron or steel centre and with the working part of bronze which will withstand corrosion. The bronze part could be cast separately and fitted on, but this method entails much labour and expense. A cheaper and thoroughly satisfactory job may be made by casting the bronze upon the iron as a centre if proper precautions be taken. Brass or bronze cast upon iron is more or less spongy or porous, and would, in most cases, be unsatisfactory as the working surface of a piece of mechanism. The method of overcoming this objection is by casting upon the iron or steel a layer of brass or bronze only half of the desired ultimate thickness of the brass or bronze. The centre, of iron and steel, should for preference be tinned, as the copper alloy will unite with the tin easily, but tinning is not essential. Its absence may cause a little sputtering as the metal is poured, but it will give as good a result as when tinning is practised. If the iron or steel be not tinned, it should be cleaned and polished. In casting, this iron or steel is used as a core, and the porous coating of brass or bronze forms a good surface upon which to cast a second and final layer of brass or bronze, which will not in this case have the tendency to be spongy. The second pouring is made when the first cast is cold and when, of course, the second mould has been prepared for it. The second cast should be given under a good head of metal so as to get a good dense casting. The two castings of brass or bronze should unite solid, and can be machined in the usual way for the finished mechanism.

Modelling. In brass castings, especially those of an ornamental nature, modelling in clay is practised in the preparation of patterns to a considerable extent. The clay model is reproduced in plaster of Paris, and from the latter tin sections are cast, or rather sections made with an alloy of three parts of lead to one part of tin. These sections, when built up together, form the working pattern for the moulder. Modelling is used in ornamental ironwork also, but we give it an extended notice in this section on account of its application in the brass foundry and because most textbooks neglect it.

Modelling is chiefly suitable for light and ornamental castings. The actual task of modelling in clay is the work where, more than in any other which falls to his lot, the workman may give expression to any artistic feeling he may possess. The general work of clay modelling has been discussed in another course [see pages 1349 and 1532], and the technical details there given permit us to be brief upon that part of the subject. The clay must be soft and pliable. It is prepared by grinding, and all stones and grit are removed. The tools necessary are few and simple. The most important are the ten fingers of the workman, and he supplements these by a few boxwood modelling tools and floats. The chief work is done with the fingers, which press and knead the clay into the form desired. The tools are used to impart the finer lines, to remove any excess of material, and generally to give the finishing touches. The work is nearly always in low relief, as high relief would be impossible without undercutting, which would not allow the finished article to leave the mould.

The work is usually done on a modelling board, stiffened at the back and coated on its surface with a few applications of shellac varnish. Thus the moisture of the clay does not penetrate into the board. This board is placed on trestles or on a bench, and the clay is placed on it and manipulated as already stated, the operator working to his drawing. If the work cannot be completed at one sitting, a damp cloth thrown over the clay will cause it to remain soft and pliable. The work finished, the clay is allowed to get somewhat firm,

after which it is removed from the board, which may be helped by pulling a piece of thin wire right down the board, meantime holding it across the full width of the board under the clay. If the impression of the clay model is to be taken in plaster of Paris, this is generally done before the clay leaves the board. The tin alloy pattern is cast from the clay on the plaster of Paris counterpart in the ordinary way, and the material, while hard enough for ordinary handling, is pliable enough to be bent and modified in shape and to have the ornamentation cut or deepened with ease and good result.

Brass Burning. In casting brass, it may be that the casting desired is too large for the capacity of the crucibles or of the furnace. The difficulty is overcome by *burning* or autogenous soldering [see following article]. The process consists in making the full-sized casting in two or more pieces; then, by placing these in their proper positions in a sand mould and by pouring molten brass so that it flows around the surfaces it is desired to join, a homogeneous casting as strong as if it had been cast in one piece is obtained. In preparing the brass castings for burning, the surfaces where the join is to take place are filed or scraped, so as to free them from scale. It is desirable that the new metal should be hot, therefore an excess of metal is allowed, the first part of the pouring flowing out through a gate and heating the surfaces as they pass over them; then the metal that remains finally comes upon the heated surfaces and the union is made.

Plate Brass. Brass which has to be subsequently rolled into sheets or cut into strips to be drawn into wire [see page 5171] must retain its ductility, hence special precautions are necessary in casting the thin plates which are to be subject to this special treatment. Sometimes iron moulds have been tried, but have never had extended favour due to the fact that the brass cools off too rapidly, although this defect might be overcome by heating the moulds before casting, and by allowing them to cool off gradually by the application of external heat.

In many places loam moulds and sand moulds are used, but granite moulds are also in extended use, and give good results if properly manipulated. A granite mould is made of two granite slabs, the lower one a little wider than the upper. Both have an even coating of clay covered with cow dung, and are kept at the proper distance apart by iron bars placed between them at their ends. The slabs are bound together with iron bands. Their normal position for pouring is at an angle of 45° from the horizontal, and as soon as the poured plate has solidified, it is removed and another poured, so that the mould remains warm. The plates removed from the mould are cleaned with wire brushes. Then they are rolled and sometimes hammered. Sometimes they are rolled hot only, and sometimes the hot rolling is finished by cold rolling. This depends upon the nature of the brass. The composition may be capable of extension by rolling only if hot. Between each rolling the sheets are annealed to give back the ductility which the previous rolling has taken from them, and before passing between the rolls they are coated with oil. If the final sheet be required soft, the last process is one of heating and quenching in water, while if a hard sheet be required, this heating is omitted.

The sheet at this stage does not resemble brass. It is black, and must be pickled—that is, dipped into a bath made of water with 10 per cent. of sulphuric acid. This may complete the preparation for the market, or another bath of nitric acid in water or a mixture of nitric and sulphuric acids in water may be given. Nitric acid dissolves zinc more quickly than it dissolves copper, so that a sheet that has come from a nitric acid bath has a surface richer in copper than the body of the sheet; hence a redder shade of brass.

Casting Bronze Statues. France is the headquarters of statue-founding in bronze. In that country the appliances and methods are the best, and the results unexcelled, and seldom equalled. The old process of statue-founding was by what is known as the *cire perdu* process [see pages 1674 and 5526], and this is still practised. By this process a rough model of the object is first made in sand or porous cement, and this is coated with wax to the same thickness as the metal which is to form the statue. Then the artist works upon this wax surface, giving the final form by delicate touches. Then several pieces of wire are pushed through the wax into the core. Now the wax is carefully coated with liquid sand, and is placed in an iron frame, which is filled up with sand. The frame is taken to a warm place, where the moisture escapes from the sand, which becomes firm. Holes are now pierced through to the wax coating, and the frame is then placed in a hot oven, where the wax melts and runs out, leaving the core supported in position by the wires which were inserted for the purpose. Bronze is now poured in by the holes through which the wax escaped, and the statue is cast. If this process produce a perfect statue, all is well, but this result is by no means certain. The operation is delicate, flaws are frequent, and if the statue be imperfect, the work of the artist has gone for nothing, because his wax model has been destroyed in the process. For this reason the *cire perdu* process has been superseded in the best French practice by a less risky process, which leaves the work of the artist uninjured if the casting be bad, so that subsequent attempts may be made without the necessity of beginning the work again *de novo*.

Piece Moulding. By this newer method the sculptor makes his design in plaster, and the rest of the work is mechanical, albeit demanding a high degree of skill on the part of the founder. The plaster statue is placed in a bed of sand, so that it may rest solid and still be comparatively safe from injury. Then the moulder begins the operation of *piece moulding*, so-called. Selecting a small section of the statue, he presses sand into every crevice in it, and obtains thereby a mould giving an exact impression of that section to which he has been devoting attention. He does the same with another section of the statue, and so on until he has the whole surface of the plaster statue impressed upon the several moulds that he has made. The plaster statue itself may now be put aside, and may not again be required. The small impressions that have been taken in sand are carefully fitted together in their proper places in the mould-box—a task requiring high skill. A rough facsimile is now made, a little smaller than the original statue, and this does duty as a core, the space between the two faces representing the thickness of metal of which the statue is to be. The mould and core are then dried in an oven to remove moisture, and to harden the sand. Vents and runners are made, and when all is ready the casting is poured. Should it be faulty for any reason the operation must be repeated; but this is not the serious matter it is by the *cire perdu* process, because the plaster statue remains upon which to work.

In statue-founding great care is taken in selecting the metal. Colour and homogeneity depend upon the bronze alloy, and no metal of which the exact composition is not known is allowed to enter. No old brass and copper are used, and the ingot copper employed is usually purified by liquation before the actual process of founding. Good work is possible only by having a highly-finished mould capable of producing a sharp casting which will require only very little chasing. The sand employed is also important. It must be carefully selected: it is usually blended to suit the nature of the work in hand, and is then passed between cast-iron rollers to give it uniformity. The moulding boxes must be accurately fitted, and their edges are usually planed.

Dressing Castings. Castings which come from the mould must be *dressed* or *fettled* before being ready for the more delicate operations of finishing. The nature of the dressing depends upon the metal under consideration, the perfection or rather imperfection of the casting, and upon the subsequent finishing processes, if any, to which it is going to be made subject. The processes of dressing castings are similar whatever metal may be employed, and we shall describe briefly the appliances used, having special regard to the fact that we are considering castings of brass and bronze.

The usual extraneous metal upon a casting as it emerges from the sand takes the form of ragged edges, fins and spurs. Cores are removed from castings usually in the foundry, and if they be large this is usually done before the casting is quite cold. A casting is *trimmed*, the first process entailing the removal of prominent spurs, by being *chipped*, by the hammer only, or, if necessary, with the assistance of a cold chisel. Sometimes pneumatic hammers [see page 5455] are used. Then fins, which are not sufficiently prominent to be properly removed by this means, are rubbed, generally with old files, which have served their first usefulness in the fitting or machine shop. Sometimes cast-iron files are used. For brass there are not the same reasons of economy for the use of old files, and good files may be employed, the brass being softer. Then the castings are usually ground. Grindstones used to be employed, but the better practice is to use emery wheels [see page 5210]. They are better than grindstones. They should not be "forced"—that is, the work should not be pressed against them with too great force, as this is bad for both the work and the tool. For large castings, which cannot be moved about over the periphery of the wheel, an emery wheel fitted to the end of a flexible driving shaft may be used. It can be applied to any accessible part of a stationary casting, but brass castings are seldom of so large size as to demand treatment by this method. But a wire brush mounted upon a flexible shaft in this manner is often used, and is valuable as an instrument for removing adhering sand.

Another process often employed for small casting is that of "rumbling"—that is, placing them in a cylindrical chamber which is made to revolve upon a horizontal axis. As this process wears the edges chiefly, it is not suitable for small castings of an ornamental nature. We have seen a similar process in pin manufacture [page 5171], and in tinning [page 6164]. Sharp sand, small star-shaped castings, known as "stars," and sometimes sawdust are placed inside the rumbling cylinders, and made to revolve with the castings under treatment. But perhaps the best method of cleaning cast surfaces is by a sand blast machine. This ingenious invention—similar to that used for decorating glass [see page 4932]—is a vessel in which a supply of sand is contained in a chamber with an aperture at the bottom, this aperture being capable of regulation as to size and as a thin stream of sand falls through the aperture it encounters an air blast—usually of from 5 lb. to 15 lb. per square inch—which carries it through a flexible tube to a nozzle, whence it is blown upon the surface of the casting. The workman guides the nozzle, and its value over the tumbling process already described is that the work can be directed to the points where it is most required, and not to prominent points only.

Brass Spinning. The die press and the draw press have modified the practice of working sheet metals considerably, not only by doing away with the need for much of the hand or "piece" work formerly undertaken, but also by making possible many forms of work formerly unattainable. The process of spinning sheet-metal is usually subsequent to the work of the press, which is an economical means of securing a blank suitable for spinning. Spinning is the operation whereby an object such as a reeded curtain-pole end, a brass bed-knob, or a berry pan, is given its shape. The operation is simple, but clever. It can be carried out upon work in the flat state which has been cut out by hand or by press, but it is economical in most cases to put the work through the draw press before spinning. For spinning, a "former" is required. This former must be of the shape which it is desired the final form of the article shall have. The widest part of the former, however, must never be larger than the narrowest neck of the spun article, else the former could not be withdrawn after the article had been spun.

The spinning lathe, in which the work is performed, is a machine with a bed and fixed headstock having a chucking arrangement suitable for holding the articles, usually of cylindrical or cup shape, or something approaching thereto. The article is held in position on the formers by a movable tail stock, and special burnishing or friction rollers carried upon a compound slide-rest are made to press against the work, and cause the metal to "flow" into the required shape, the form being given by applying the pressure at the proper points. It is possible to give by spinning not only plain ridges and grooves, but ornamental patterns, such as milled, beaded, and spiral edges, such forms being attainable by the use of pressing rollers and formers carrying the particular pattern it is desired to impress upon the work. For spinning work, the result depends upon the high speed at which the work is made to revolve. The operation we have described utilises burnishing or friction rollers attached to the slide-rest. This is the modern practice, and is the best for cheap work where thousands of one article are being made, but for some work, other than brass, such as spun Sheffield ware, it is common to use burnishers, held by hand and pressed against the work without mechanical aid other than the strength of the workman.

Continued

GARDENS IN TOWN & COUNTRY

Garden Tools. The " Back Garden" in Town. Window Decoration. Trees and Shrubs for Town and Country. Walks and Lawns. Rock and Water Gardens

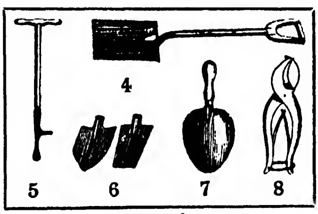
Continued from page 6206

By HARRY H. HAVART

The Gardener's Tools. The most important garden tool is, of course, the spade [4], which is an implement perfectly distinct from the shovel, although the names are often interchanged, and one tool used for the purpose of the other. The spade is used for digging, and the bottom of the blade should be of steel, and the upper part of iron, thoroughly welded together. Young gardeners often suffer pain, when digging, from the pressure of the foot on the tread, or shoulder, of the spade. This can be obviated by using a little contrivance called a " digging shoe," a sort of anklet of leather which buckles over the middle of the foot, so that there is a good layer of leather acting as a protector where the foot presses on the spade. Spades are made in four sizes—1, 2, 3, and 4, of which No. 3 is probably the most useful implement.

The Shovel, Fork and Rake. The shovel [6] is used for shifting loose soil, clearing trenches, handling manure, and similar purposes. Its blade is broader than that of the spade, and it is usually pointed, so that it can be pushed into piles of loose earth more readily than the spade. A shovel with a long handle is the best, as this obviates the necessity for stooping.

The garden fork is a most useful, though somewhat neglected implement. Much of the work of breaking up ground, which is at present done with the spade, could be done far less laboriously with the fork. A four-pronged fork is the most useful, though some are made with three, and some with five prongs. The fork is particularly useful in stirring the surface soil between plants, to aerate it. Short-handled forks are handy implements for taking up small roots, transplanting, or weeding, being, for this purpose, generally handier than the trowel.



GARDENERS' TOOLS
4. Treaded spade 5. Bulb planter 6. Shovels 7. Trowel 8. French secateur

The rake is not so much used as formerly, except the wooden variety, which is used for removing dead leaves from lawns, and other similar purposes. There is a variety of rake, however, called the " daisy rake." This has short teeth very close together. It is used to drag over lawns, to pull off the heads of daisies, dandelions, and other lawn weeds.

Lawn Mowers and Other Tools. Lawn mowers vary a good deal in detail, but most of the best makes are so equal in merit that there is little to choose between them. It is well to consider the area of the grass to be mown in selecting a lawn mower as far as size is concerned. A large lawn mower on a small lawn means expenditure of unnecessary labour, and the same remark applies to the opposite condition—a small mower on a large lawn. The chief thing to be observed is to keep the cutters properly sharpened, as an attempt to mow a lawn with blunt cutters is simply waste of time. The edges of grass which the mower cannot well reach must be cut by means of shears, which are made with both straight and curved handles.

The pruning knife has been almost superseded by the secateur [8]. This instrument is really a sort of miniature shears, and, in the hands of an inexperienced gardener, is certainly a much better implement than a pruning knife as it makes a cleaner cut, and there is less danger of cutting away too much with it.

The trowel [7] is an indispensable little implement for transplanting cuttings and small plants. First of all the hole to receive the plant should be made, and then the trowel should be used to scoop around the root of the plant, and lift it out bodily, when it can be carried on the trowel and placed in the hole prepared for it. A bulb-planter [5] is particularly useful for planting bulbs in lawns.

Other gardener's tools include the watering-pot, wheelbarrow, saw, and hammer, the uses for which are obvious.

The Little Back Garden. The poor little square patch which is known to the town dweller as the back garden is the most handicapped piece of soil in the world. It is situated so that surrounding walls and sides of houses either cut off air, light and sun from it altogether, or else admit the blinding glare of the sun's rays to scorch the ground up, while effectually screening any refreshing breezes. Further, the prevalence of smoke chokes up the pores in the stems and leaves of the plants, and prevents them from breathing, while the elaborate systems of drainage with which all towns and cities are replete, act indirectly upon the gardens by drawing away the moisture from the subsoil. Without this moisture in hot weather the roots of plants can never be healthy, and success in cultivation becomes more difficult.

Laying out the Small Garden. These little back gardens are usually square, and where any attempts at gardening are made they generally take the form of a narrow border running all the way round, while the remaining space is devoted to turf, with, perhaps, a circular bed in the centre.

The one point in favour of this plan is its simplicity, but it has the effect of making a garden look hard and formal. A more picturesque way of laying out a small garden is to make the border of an irregular width, curving it in and out as fancy directs, easily and gracefully, though never in such a complicated manner as to appear grotesque.

The centre of the garden can either be laid out simply as grass (the best method where there are children, as it gives them just a few yards to play in), or it may be broken up by arranging for the planting of one or two flowering shrubs, or by the introduction of a bed or beds as may be desired. A very interesting and easily-attained feature of a town garden is a small bed treated as a rock garden, particulars of which are given later.

Trees and Flowers in Town Gardens. Large trees are a mistake in a very small city garden. Although it seems a pity to advocate the cutting down of even one tree, there can be no doubt that their presence in a tiny back garden is a grave menace to the health of the inhabitants of the house, and also militates against success in growing plants, owing to the terrible drain it is upon the nourishing elements in the soil. The same remark applies, to a certain extent, to laurels and privets, which form the lazy man's garden.

The names and habits of many flowers and plants suitable for city culture will be found in future pages, but for general use it may be mentioned that the two most useful climbers for hiding walls and fences that face the east or north are the Virginian creeper and Rægner's, or a variegated ivy. Variegated ivies like poor soil; it brings out the variegations better. For sunny situations, purple and white clematises, Veitch's ampelopsis [11], or vine, Canary creeper, Japanese hop, and yellow, winter-flowering jasmine are the best. Of shrubs, the best are the mock orange, aucuba, flowering currant, variegated euonymus, rhododendrons, and Syrian hibiscus.

These may be put in when the laying out of the garden is first begun. If put in in the autumn, a handful of straw laid round the bottom of the stem will prevent the frost from getting at the roots.

Window-boxes. Every window, whatever its aspect, can have a box upon its sill in which flowers will grow [11]. Such boxes, with tiles or ornamental fronts, are to be bought, but there is an easy way of making them. Measure the window-sill, and make a box to fit it, about 9 in. deep. Get a piece of clay and daub it, putty-wise, along all the joins and corners, so as to make it watertight. To each bottom corner nail a strip or block of wood about 1 in. in depth, so as to prevent the box from standing close on the window-sill. In the middle of the bottom of the box bore three or four small holes, about a couple of inches apart from each other to allow superfluous moisture to drain away.

9. RHODODENDRON BLOOM

Then paint the outside only of the box a dark green or brown. Fill the box to about one-third its depth with bits of broken flower-pots, china, brick, stone, or any similar material, to form drainage, and then fill it up with earth which has been carefully picked over, or sifted, to get rid of all big stones, and well mix with silver sand. The window-box need not be a thing of beauty in the summer-time only. When gardening operations begin in the autumn, some dwarf conifers should be put in to keep the boxes bright during the winter, and at the same time bulbs must be planted to keep them gay from March till June, by which time the spring-sown plants will be bursting into bloom.

One of the most important points in connection with window-box gardening is that the plants should have sufficient water in the winter time. It is just the season when plants fully exposed in the open air are being soaked by wet and snow, so that if the window-box is in a sheltered position it should be watered, if not as frequently as in the summer time, at least twice a week.

Trees and Shrubs for the Town. It is impossible to expect a good garden if the trees and shrubs which it contains are either of the wrong sorts, or are wrongly planted.

Of the trees most suitable for planting in town gardens, the following is the best selection: Sycamore, common almond, plane, poplar, common elder, horse chestnut, American cherry, ailantus glandulosus, and most of the hollies, which, although of slow growth, will more than repay the care bestowed upon them within a few years after planting. The same remark applies to the euonymuses, of which the variegated sorts are preferable, their foliage being brighter and more pleasing.

Many of the privet hedges now to be found in surburban gardens might, with advantage, be replaced by box, which, although of slow growth, is neater in appearance, and readily kept in hand. An excellent, though much neglected, tree for a suburban garden, especially where there is anything in the shape of a lawn, is the black mulberry (*Morus nigra*). Not only does it thrive under the most unfavourable conditions, but yields a generous supply of delicious fruit in the autumn. It is for this reason that it must be grown in grass, as otherwise the fruit, which should not be gathered, but allowed to drop, will be injured when it falls to the ground. The presence of the turf prevents it from getting damaged.

The best evergreen shrub for town planting is undoubtedly the rhododendron [9]: until lately it was thought to be not quite hardy, but by means of hybridisation many kinds, embracing all colours, are procurable. The old-fashioned ponticum rhododendron is now usually relegated to countryside coverts.

Trees and Shrubs for General Planting. Trees and shrubs which may be used for general purposes in gardens throughout the country embrace some thousands of species. Many of these will thrive only in the sheltered gardens of the South and West of England, and it is useless to attempt to grow them in other districts. They are divided into two classes, one known as deciduous, or summer leafing, and the other as evergreen. The latter class is green all the year round, while, during the winter months, the deciduous kinds have nothing but bare stems to show. At the same time, the most brilliant displays of bloom are usually to be found on the summer-leafing shrubs and trees.

A list of the most useful evergreen trees and shrubs includes the following: Andromeda, arbutus, aucuba, berberis, cerasus, choisya ternata, cistus, cotoneaster microphylla, daphne, elæagnus, erica, escallonia, euonymus japonicus, garrya elliptica, hedera, ilex, kalmia, laurus nobilis, olaria haasti, quercus ilex, rhododendron, skimmia, ulex europæus veronica, vinca major and vinca minor, and yucca gloriosa.

The following are among the best of the summer leafing sort: Acer, aesculus, ailantus glandulosus, alnus, amelanchier, amygdalus, aralia spinosa, azalea, berberis, betula, buddlea globosa, calycanthus

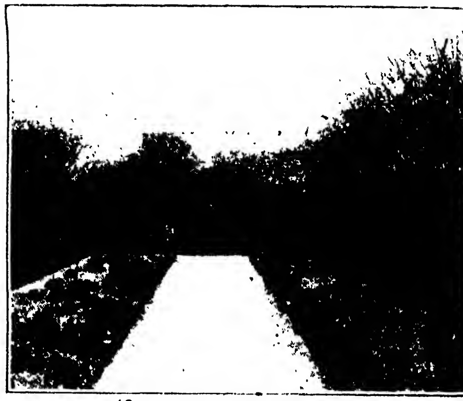
floridus, carya, catalpa bignonioides, cerasus, corylus avellana, cotoneaster, cratægus, cytisus, daphne mezereum, deutzia, elægnus augustofolia, fagus, forsythia, fraxinus, genista, hamamelis, hibiscus, hydrangea, juglans regia, kerria japonica, laburnum, liquidambar, liriodendron tulipifera, magnolia, morus, persica vulgaris, philadelphus, platanus orientalis, populus, prunus, pyrus, quercus, rhus, ribes, salisburia adiantifolia, salix, sambucus, spiræa, syringa, tamarix gallica, tilia, ulmus, viburnum, and weigela.

How to Plant Trees. Upon the proper planting of trees at the outset their future welfare depends. It is not sufficient merely to dig a hole in the ground, cram the roots of the tree or shrub into it, throw back the soil, and make the whole thing firm by stamping upon the base of the stem with an iron-shod boot-heel.

In preparing a hole for the reception of a tree or shrub, it is best to dig it wide and shallow, rather than narrow and deep. The roots should be examined carefully before planting, and any that are broken or injured cut away with the pruning knife, or secateur. The roots should be well spread out in the hole, and the soil gently but firmly pressed in. Should the weather be dry, the young plants should have a liberal dose of water as soon as they are put in the ground. Trees or shrubs that are planted on hillsides, or in other open situations, where they are likely to be exposed to the full force of the wind, should be supported by means of stakes driven firmly into the ground, to which they should be fastened, the stakes being left in for two seasons.

The Time for Planting. Trees and shrubs may be planted with safety at any time between the late autumn and early spring, say from November to March. The bulk of planting is usually done in the autumn, as at this time work is slacker in the majority of gardens than it is after the turn of the year. In town gardens, however, and others in which the soil is of a poor quality, advantage is often to be derived by deferring the planting till the spring. The reason for this is that the roots have the whole of the summer in which to get established before being called upon to undergo the rigours of a winter.

Planting should never take place in wet weather, or when the ground is sodden with moisture, as shrubs and trees planted under these conditions are more likely to rot than thrive. It is also useless to attempt planting when the ground is frozen hard, for not only is digging then almost an impossibility, but the soil cannot be properly replaced, and frost will percolate to the roots through the crevices left, and kill the plants. When, of necessity, planting must be done in frosty weather, it is well to cover the surface of the ground round the bases of the stems with a layer of straw, litter, or other mulch, to afford protection from frost.



10. CLIPPED YEW HEDGES

Transplanting Large Trees. To transplant a large tree, it is first necessary to expose its roots. This is best done by loosening the soil around the base of the tree, preferably with a fork, for a distance which corresponds to a spread of two-thirds of the distance covered by the branches above. The soil should be carefully cleared away with shovels, care being taken not to injure the roots, which should be lifted up out of harm's way as exposed. When the soil underneath the tree has been well tunnelled, a shallow trolley should be run underneath and the tree carefully levered on to it, being held in position by props consisting of young larch poles, and secured with ropes. If the roots are not wide spreading, it is well to lift the tree with as large a ball of soil attached as possible, as this not only prevents damage, but helps the tree to more quickly establish itself in its new surroundings. It is important that a transplanted tree should have the same aspect as it did originally; hence before moving it is usual to mark one side of the tree with a dab of whitewash.

Making Woods and Shrubberies. The trees most generally employed in the making of woods are the fir, pine, beech, birch, oak, larch and, to a smaller extent, the elm. This latter tree has fallen into considerable disrepute, especially for belts, or avenues, overhanging roadway or path, where it is often a considerable source of danger. This is owing to the fact that for some reason unknown up to the present, branches apparently sound, often weighing many hundredweight, are liable to break off suddenly and fall to the ground without warning.

Oak plantations are, in the fulness of time, the most profitable of any, but the reason that so little young oak is laid down at the present day is that it is of very slow growth, and few landowners are prepared to lock up the capital entailed in the establishment and maintenance of oak woods.

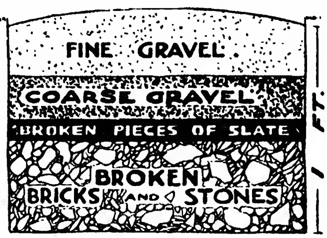
The system which has been found to answer best in making a plantation is to employ nursery grown plants from two to three years old. These are inexpensive, ranging in price from about 5s. per thousand

11. THE WINDOW-SILL BEAUTIFUL
(Pelargoniums and ampelopsis)

for the cheaper sorts of firs up to 30s. per thousand for oak and the other choicer varieties. Opinions differ as to the best distance apart at which to plant these young trees, but a good all-round rule is to allow a space of 5 ft. every way between them. It is usual to "nurse" trees of slower growth, such as oak, by planting a quick-growing timber, such as larch, between them. By the time the oak is sturdy enough to take care of itself, the larch may be thinned out and cut down, if it is not desired to retain it.

Some of the tenderer growing firs are often "nursed" in a similar manner, but there is a simpler way in dealing with this variety of tree. This is to sow the ground, when planting the young firs, with seed of the common gorse, which, being a very rampant grower, speedily affords all the protection needed. Care must be taken not to let it go too far, however, or the gorse may choke a large number of the young conifers. Many firs have a tendency to develop what are called side breaks. These are shoots which appear near the top of the tree, so that instead of tapering away gracefully to a point, as it should do, the centre stem breaks away in three or four directions, not only destroying its symmetry, but greatly lessening its commercial value. These side breaks should be cut off in the early stages of growth.

Where not to Plant Trees. Much care must be exercised as to the position in which young trees are planted. The gardener who fails to look far enough ahead is apt to place them where, although they are very pretty and effective for the time being, they will be the source of great trouble, say, fifty years hence. Trees should never be planted quite close to a house. First of all there is a danger that the roots may spread sufficiently to injure the foundations of the building; secondly, if the house be a low one, there is risk of damage from the dripping of the rain upon the structure as it falls from the leaves and branches; and, thirdly, the presence of big trees near a house interrupts the free circulation of air, and consequently makes the place damp and unhealthy.



12. MAKING A GRAVEL PATH

It is not wise, either, to plant a tree quite close to the edge of a path, for, as it grows older, it will be found necessary either to alter the course of the path or remove the tree.

Making Hedges. A living hedge is always better than a dead wall, and wherever they can be used in gardens in the place of dividing lines of wood or brick, hedges should certainly be planted. Unfortunately, practically all the trees which go to form good hedges are of slow growth, and take a good many years to form a substantial barrier. The quickest growing of all hedge plants is the privet, and this is probably why it is seen so much in every little suburban front garden. At its best it forms but a straggly barrier, and where, owing to circumstances, it cannot be dispensed with, its ugliness may be redeemed by employing one of the variegated sorts. Plants about a foot in height should be used, and they should be put in in the autumn or spring, at a distance of about 9 in. apart, or closer to form a thick hedge.

The best hedge of all is the holly hedge, but this is one of the slowest to attain respectable dimensions. Plants 2 ft. in height are the best to begin with, planted from 1 ft. to 2 ft. apart, according to their size. They should not be trimmed for at least two years after planting. An old holly hedge forms a barrier that nothing can get through, especially if it be clipped regularly.

The ordinary hawthorn hedge requires practically the same treatment as the privet, though, if it is not cut back within a year or two after planting, it is apt to get very "leggy," the lower part being nothing but a collection of stems.

A yew hedge is probably, next to the holly, the densest and most compact, provided it is clipped regularly in the early spring, before the young growth commences [10]. It should, however, only be used inside a garden, and not to form a boundary by a road or field, or any other place where horses or cattle will be likely to get at it, on account of its poisonous nature.

A Hedge of Sweetbriar. One of the most charming garden hedges may be formed by the employment of sweetbriar. Though this is very little used generally, it makes the most fragrant of all hedges, and deserves to be much more widely known than it is for this purpose. It can be planted at any time when the roses are being planted, and can always be clipped into a neat, compact hedge. This is quite hardy and simple for town use, and is full of perfume during the summer months, in direct contrast to the privet, which, at this time of the year, bears evil-smelling flowers of a dirty white colour.

Near the seaside the euonymus makes a splendid hedge. Particularly is this the case on the South Coast, most of the favourite Sussex watering-places having excellent examples of what can be done with this plant for hedge-making. The tamarisk and the sea buckthorn are also useful in these situations.

During the early years of a hedge's life, it is necessary to watch the young plants very closely, and remove all dying or weakly specimens, otherwise, when the hedge attains maturity, gaps where weakly plants have been will be disclosed.

In clipping hedges, no matter of what composed, they should be cut wedge-shaped, to a certain extent, the narrowest part being at the top. In this way the lower portions are not overshadowed, and thick growth at the base is encouraged.

Walks and Lawns. The making of walks and lawns, and the preparation of formal beds for the latter, are branches of gardening which have to be carried on in such near relation to each other that they should be studied simultaneously.

Most gardens have too many walks. In public parks, certainly, a large number of paths is necessary, because it is only by providing this sort of accommodation for them that a crowd of sightseers can be kept within bounds. No such precaution is necessary, however, in a private garden, where the majority of the walks should be grass ones, prepared and looked after in the manner recommended for lawns. It is impossible to lay down a hard and fast rule as to where a gravel path should be put, as conditions differ in practically every garden of decent size. The carriage drive, of course, must be gravel, so must the main walk to the kitchen garden, the one to the glasshouses, and others which are being tramped over every

minute of the day. An economy, both of time and labour, is effected by making most of the others grass walks.

Unless the exigencies of space compel, it is better never to make a gravel walk a perfectly straight one. Such a path, running hard and uncompromisingly out in the perspective, is rarely a pleasing sight, even if fringed by the choicest flowers. At the same time it is absurd to make a path wriggle all over a garden for the mere sake of doing so.

Nowhere in the world are such lovely lawns to be found as in our own gardens, and few things are more refreshing to the eye, or more beautiful, than an expanse of smooth, unbroken turf. This fact should be borne in mind when laying out a garden, and care should be taken to keep all beds near the edge of a lawn, and not to go dotting them at regular intervals all over the turf just for the sake of symmetry. Such a garden is sure to be hard and unnatural.

How to Make Walks. The first step in the making of a walk or path is to map out exactly where it is to go. In the case of a large garden, a plan must be prepared on paper first, otherwise confusion will invariably result: but with a small garden this is not necessary. Then the course of the path must be traced out on the ground by means of cords, to which, at intervals, small pegs are attached. These strings and cords are one of the gardener's most important tools in the early work on the ground, as they serve to outline every bed and border, and determine the width and direction of every path.

When these points are satisfactorily settled, the soil, to the depth of about 1 ft., should be dug out all along the course of the proposed path, and carted away. Needless to say, it will be much appreciated elsewhere. At the bottom of the trench thus made a layer of broken bricks and large stones should be distributed in as level a fashion as possible, to the depth of 6 in. or 7 in., for the purpose of drainage. These should be well crammed down, and covered with 2 in. or 3 in. of coarse gravel, which must be well rolled in. Upon the top of this the final layer of fine gravel rests, to the depth of 2 in. or 3 in. In building up the path the surface should be made a little higher at the middle than at the sides [12].

If available, a layer of pieces of broken slate, about 2 in. in thickness, should be placed between the broken brick layer and that of coarse gravel, as worms cannot penetrate this material, and unsightly worm-casts are prevented. Much rolling is necessary when a path is first made, as otherwise the top layer will never become hard and firm.

When once a walk or path is made, there is always the task of keeping it free from weeds to be considered. By far the most efficacious way is, of course, to pull up the weeds by the roots as fast as they make their appearance. There are many chemical weed-killers on the market, but they require very careful handling, as not only do they kill weeds, but everything else with which they come in contact. A dressing of salt is a pretty effective weed-killer, and an application of boiling water serves a similar purpose.

13. WATERSIDE PLANTS, KEW GARDENS

A stone path is a good path if properly constructed, and is always practically dry. In constructing such a walk, proceed as indicated for gravel walks, until the layer of coarse gravel is laid and rolled. Upon this should be laid just an inch or so of soil, and in this, embedded roughly, shaped pieces of flat sandstone, in the form of an irregular mosaic. Old paving-stones, such as may be procured from any contractor's yard, and broken up with a sledge hammer into pieces of any size from 6 in. to 2 ft. across, are excellent material for the purpose. As these are embedded, a little soil should be pressed into the chinks between each piece, and in these chinks stonecrops and mosses may be planted. These will quickly establish themselves, and form a very pleasant walk in the course of a season or so. Such stone walks are, as yet, comparatively rarely met with, but their many advantages over the gravel walk, and their picturesque appearance, are gradually bringing them into favour.

The Making of a Lawn. There are two ways of making a lawn—by turfing and by seed. In places where, in forming the garden, good turf has been cut off and stored from parts of the ground when levelling is going on, it may well be replaced; but where an entirely new lawn has to be made it is better to employ grass seed than to purchase turf and lay it.

Before sowing, an operation which is best carried out in the springtime, the ground should be well dug over with a spade, all lumps being broken up with a garden fork, and afterwards gone over with a rake, to ensure that the surface soil is nice and fine, and, moreover, free from stones. Then go over it with the roller, being careful, especially in the case of a tennis lawn, to see that it is quite level.

As soon as the surface is nice and smooth, it is ready to receive the seed. The regulation quantity of seed, as recommended by all the leading authorities, is 1 lb. of seed to every 16 sq. yd. In other words, a bushel of grass seed will sow

14. A MIXED BED (Mostly *Lilium speciosum rubrum*)

an area of 400 sq. yd. Two apparently trivial but really important points must be observed when sowing a lawn. There must be no wind, and the sower must not wear high-heeled boots. Grass seed is very light, and even a moderate breeze would blow it into uneven patches as it leaves the sower's hand, while high heels would dig into the ground, in its unsettled state, and disturb the level. A pair of cheap canvas shoes with indiarubber soles and no heels are the best footwear for this work.

When the seed is sown it should be covered by just the slightest covering of loam or sand, and rolled lightly. If the soil be a heavy clay, the covering of sand will be the best, while if the soil is in itself a light one, it will benefit more by the sprinkling of loam. This must in turn be rolled, but lightly, otherwise the delicate little blades of grass might find difficulty in forcing their way to the surface. Where there is any danger of the seed being attacked by birds, black threads should be stretched at intervals across the ground, 2 in. or 3 in. above the surface.

The new lawn should not be rolled or swept until the grass is 2 in. or more in height, when it may be rolled lightly and swept gently. A lawn mower should never be used to a new lawn, as it is apt to tear the tender young grass up by the roots. The scythe is the proper implement to employ for this purpose. This operation should be carried out early in the morning, when the dew is on the grass, as the scythe works best at these times. The mowing machine, which may be used when the summer comes and the grass has got well established, works best when the ground is dry, and may therefore be employed at midday. To ensure a good velvety turf, a lawn should be well mowed and rolled at least once a week. Daisies, dandelions, and other weeds should be rooted up without mercy by the instrument known as a daisy fork.

15. A PINK-FLOWERING WATER-LILY
(*Nymphæa rosea*)

Carpet-beds on Lawns. A carpet-bed is a bed formal in outline, and also in the nature of its contents, which are composed of dwarf plants of a similar height, arranged in a set pattern, sometimes to form a word or motto, or else according to a geometrical plan, so that they resemble a part of a pattern or a carpet. Carpet-beds are not by any means the only sort of beds that can be made on lawns [**14**]; but as lawns are the only place for them, and their preparation is really part of the garden design, it is best to deal with them here.

Many gardeners maintain that to arrange plants in such a formal way is an outrage upon Nature, and ought to be tabooed; while, on the other hand, there are many gardens in the kingdom where carpet-bedding is carried to excess, and the only effect is a hard and ugly one.

The best way is to strike an intermediate line, and have a little carpet-bedding, if it be desired, near the house, whence the bedding can gradually get less and less formal, until it merges into the wild garden.

Before making a carpet-bed, the design should be drawn out on paper, and marked with the names of the plants it is proposed to use in each section to give the varying colours. If the bed is to be circular, it is usual to peg out a square on the site, and then cross it with two diagonal strings. Where these strings meet is the centre of the bed. Place a peg there, with a string attached, and, just at the point where the string touches the side of the square tie an old knife, steel point, edging tool, or anything that will cut the turf. Then, by dragging this round the ground, a perfectly circular cut will be made.

Plants for Carpet-bedding. The soil for a carpet-bed should be broken up fine, or sifted, for preference, and a little sand mixed with it, unless the soil is already sandy itself. Before, however, the work can be proceeded with any further it is necessary to prepare the plants which are to fill the carpet beds. These are a class by themselves, and their culture is of the simplest. The pyrethrums, which give gold, pale green, grey, and yellow tints, are grown from seed, which must be sown in a greenhouse, with heat, in early spring, in boxes of sandy soil, and will be ready for putting out in the bed in May, which is quite soon enough, in order to escape the possibility of a touch of late frost. Red and blue lobelia are treated in a similar manner.

Alternantheras are another important family for carpet beds, and their colours range from yellow to red, but cuttings of these must be purchased in the first instance as seed is not readily procurable. These cuttings must be put into sandy soil, and rooted on a hotbed. A hotbed is made in a frame, or frames, in the garden, and consists of a layer of about 18 in. of manure, covered with a good layer of soil. The decomposition of the manure induces heat, and this heat causes the cuttings to take root and thrive. As the spring progresses, the glass top of the frame should be raised during the day to allow the young plants to gradually harden off.

Other prominent carpet-bedding plants are iresines, antennarias, stonecrops, and Herniaria glabra, while the familiar rosette shaped plant often seen round the edges of carpet beds is known as Echeveria secunda.

When the plants are ready for putting out, the pattern of the bed must be carefully mapped out on its surface in silver sand, and the young plants put in, about 2 in. apart, with great accuracy, commencing at the centre and radiating outwards.

A carpet bed, carefully prepared, will last on into the autumn until the early frosts spoil it. It should then be cleared, and, in order to avoid ugly brown beds during winter, they should be planted with dwarf evergreens and bulbs of snowdrop, crocus, and early-flowering daffodils, the culture of which will be dealt with elsewhere.

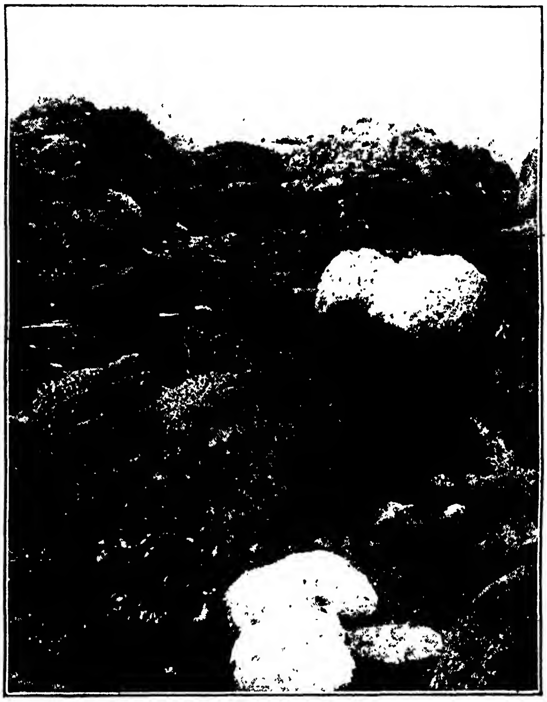
The Rock Garden. Rock gardens, as at present constructed, are, generally speaking, capable of a great deal of improvement, and in preparing one its true purpose should not be lost sight of. This purpose is, in the main, to enable the choicest Alpine and other mountainous plants to be grown in this country under as natural conditions as possible. Therefore the piling up of masses of rock and stone with no thought for the needs of the plants that are to adorn them is not at all likely to produce satisfactory results. Worst of all, perhaps, are the masses of burnt brick which are found in many gardens, tossed about in heaps,

and crowned with a few hardy ferns, which would probably thrive ever so much better if planted in the garden in the ordinary way.

The spring is the best time of the year in which to commence making a rock garden, and a sunny position in the garden is the best spot at which to construct it. It may be of any size, but should be irregular in shape, though there is no need to go out of the way to make it curious in this respect. If the soil is not good and deep at the spot where it is proposed to construct the rock garden, the ground must be dug out to the depth of 18 in. or more, and a good mixture of peat, loam, and sand put in its place. This bed of soil should be raised well above the level of the surrounding ground, or a picturesque effect will not be obtained. The so-called rocks may be pieces of any kind of stone which is common to the district. In fact, in towns, many effective little rock-beds can be built up by employing pieces of ordinary sandstone pavement, broken up into irregular shapes. Sufficient for the purpose can generally be procured at a nominal price at any builder's yard.

The whole secret of successful rock gardening is this: Plants suitable for growing under these conditions require full exposure to the sun, though at the same time they must have plenty of moisture at the roots. Hence the real use of the rocks is to act as a shield and prevent the evaporation of the moisture so essential for the well-being of the plants.

There are some shade - loving rock plants, but they are comparatively few in number compared with the others. It is impossible to lay down any hard and fast rule as to how pieces of rock should be arranged in every garden—so much depends upon position and surroundings in each instance. Individual taste must be brought to bear upon the matter, taking care to avoid all trace of formality and "building" [16]. Rock gardens should never be made near trees, as their shade destroys the very object with which it was constructed.



16. A WELL-MADE ROCK GARDEN

When first constructing a rock garden it is best to put a few pieces of rock in the most prominent positions, and then insert the plants, gradually embedding the minor pieces of rock in the soil as the planting goes on. In this way not only is a more natural aspect assured, but the plants are more securely rooted than they would be if the rocks were arranged methodically at first, and the plants tucked in between the crevices afterwards. One or more members of the following families go far to make up a representative collection for the sunny part of the rock garden: Alpine harebell, orchis, Alpine anemone, stonecrop, allium, androsace, antennaria, arnebia, armeria, chionodoxa, colchicum, daphne, Alpine pink, sea-holly, dog's-tooth violet, geum, iris, leucojum, lithospermum, muscari, pentstemon, Jacob's-ladder, potentilla, primula, saxifraga, sempervivum, sternbergia, trillium, trollius, foamflower, and viola. Those which thrive best in shady situations are the lady's slipper (hardy cyrpripedium), gentian, ranunculus, epimedium, hepatica, and iberis.

Water Gardens. It is quite possible to construct water gardens in places of modest dimensions; in fact, there are many instances in which water lilies have been successfully grown through no more ambitious medium than a half-barrel sunk in the ground. The orthodox method of making a pool in a country garden is to dam a stream at some convenient spot and form a pond of the overflow.

Where there is no stream at hand, the water must be brought to the spot by pipes, unless the owner is satisfied with a stagnant pool. First of all the piece of ground which it is proposed to transform into a water garden should be dug out to the depth of 3 ft. or 4 ft., and the soil carted away. The edge of the hollow thus made should be purposely left irregular in shape, as, if it is cut square or circular in form, the effect is formal and unpleasant. A layer of clay about 1 ft. in thickness should then be spread over the bottom of the basin, and thoroughly beaten into the ground. This operation of beating is most important, as it is to render the basin watertight, and if carelessly done the water will leak away. On top of the clay a layer of good loam from 6 in. to 9 in. in thickness should be spread, and the water may be let in.

Water Lilies in the Small Garden. Even where the only water available is the half-barrel just alluded to, it should be sunk well below the level of the ground, and the formal edge broken up with a few groups of moisture-loving plants. The best form of barrel to employ is a petroleum or beer cask. It should be sawn in two, and charred on the inside so as to remove all traces of oil or alcohol. It should then be pitched on the outside, after which it is ready to be plunged into the ground. At the bottom of the barrel place a layer of good stiff clay, and on top of this a few inches of a compost of two-thirds good fibrous loam and one-third old, well-decayed leaf soil. This should leave ample room for about 1 ft. of water, which

can be poured gently in after the water lilies have been planted.

Planting water lilies in the water garden is merely a question of getting an openwork basket, filling it with soil, and inserting the tuber. A stone should be tied to the basket to prevent it being washed away, if the water has a current. Water lilies thrive best when fully exposed to the sun, and the best time for planting is during the months of April, May, or June. The following nymphæ are the best six to plant: Alba, Rosea [15], Froebellii, Laydekeri, Odorata, and Robinsoni. Other flowers which should be planted in the water itself are nuphar (often mistaken for a water lily), the Cape pond-flower, buckbean, arrowhead, reed mace, arum lily, bullrush, and the water forget-me-not.

As the banks of a water garden are sure to be damp and marshy, they should be liberally planted with moisture-loving things in the springtime [13]. Among the best of such plants are the Japanese iris, marsh marigolds, globe flowers, several varieties of the hardy bamboos, day lilies, American swamp lily, royal fern, and several of the arundo, or reed family.

The Wall Garden. The wall garden is almost a thing of the past, except in old-established places, notably those in the West of England. This is probably due to the fact that brick walls and wooden fences have practically superseded stone as boundary lines.

A good wall garden is, however, always a charming sight, and may, for the sake of illustration, be called a vertical rock garden. The whole system of wall gardening consists in planting suitable subjects between the chinks and on the top of stone walls, taking care that such chinks have sufficient soil to enable the plants to live. The best of all these plants is, naturally, the wallflower itself (*Cheiranthus cheiri*), which is sometimes found self-sown on the sides of disused quarries, chalk pits, and in other similar situations. It seems to thrive on practically nothing, growing almost on the bare rock itself. The majority of wall plants are rock-garden plants as well, though their number is necessarily limited, as most rock plants are deep-rooting subjects. Varieties of the following are among the most suitable: Alyssum, arabis, erodium, gypsophila, linum, polypodium, saxifraga, sedum, and sempervivum.

Climbing Plants. One of the principal features which make or mar a garden are climbers. This is particularly noticeable in gardens of modern formation, which are usually those attached to ugly houses. So few modern-built houses are handsome in appearance that it is a good thing to clothe them, as far as possible, with climbing flowers and plants. It is not only against the walls of houses that the climbing plants are both beautiful and desirable, but out in the garden itself, where summer-houses, arbours, covered walks (which are known as pergolas), walls, fences, old tree stumps, and many unsightly objects may be improved by their use. In many cases, indeed, climbing plants may be allowed to grow over living hedges and up tree trunks, though in this last capacity they should be employed in moderation: if used to excess, the result often gives the impression of careless gardening. The climbing plants most sought after are, naturally, those varieties of the rose which have this habit. They will thrive in almost any aspect, though, naturally, such good results cannot be expected on a wall facing north as in more sheltered situations. In a loamy soil, which is about 2 ft. deep, however, they would do well, even in many town gardens. It is a mistake to prune climbing roses too freely; nor should they be nailed against the wall at every few inches, as if they were undergoing a species of crucifixion, but only given such support as is absolutely necessary, so that they can make their way upwards as naturally and gracefully as possible. This remark applies to practically all climbing plants. The best of the climbing roses are: Reds—Crimson Rambler, Chesunt Hybrid, and Waltham Climber. Yellows—Maréchal Niel, Gloire de Dijon, Bouquet d'Or. White—Aimée Vibert and Niphetos. Pink—Climbing La France and Pink Rover. Apricot—William Allen Richardson, Rêve d'Or, Madame Berard.

Clematis and Creepers. Next in importance to the rose as a climbing plant is the clematis. Most of the varieties are grafted on wild clematis. The most useful hybrid for general purposes is Clematis Jackmani, the large purple flowers of which are so often to be seen in town gardens. It has a variety—Alba—whose flowers are equal in size and number, and white in colour. The clematis flourishes well in a light soil, and flowers freely from May to July.

Other spring and summer flowering climbers include the wistaria, white jasmine, and the honeysuckles, while seed of the common climbing nasturtium and canary creeper, sown at the bottom of an arch or arbour during the month of April, will cover it in a month or two. Being annuals, such sowings must, of course, be renewed every year.

For exposed situations there is, of course, nothing to equal the common ivy, or one of the variegated sorts. This has the advantage of being evergreen, and is consequently in evidence all the year round. The Virginian creeper is noteworthy for its beauty in autumn; but after the leaves fall it presents a very untidy appearance. A much neater climber of this class is Ampelopsis Veitchi.

Winter Flowering Climbers. There are three climbers which are of inestimable value, as they flower in the winter time. Two of these are admirably adapted for town gardens. The best is the yellow-flowered jasmine, which, though its stems are bare at the time, is covered during the most unfavourable months of the year with a shower of bright, yellow blossoms of diminutive size, which make a brilliant contrast with the dark-brown stems of the plants and the brick walls.

The second perfectly hardy winter climber is the pyracantha, which it is hardly accurate to describe as "flowering," as it is its bright orange-red berries and rich dark evergreen foliage which render it valuable during the dark days. It thrives with equal vigour in any sort of soil.

In favoured situations the winter-sweet (*Chimonanthus fragrans*) may be grown on a south wall. Like the jasmine, its flowers are borne on bare stems. It is particularly sweetly scented, and if the flowering shoots are cut and floated in a shallow vessel of water, they will diffuse their fragrance through a dwelling-room for many days. No harm is done by treating the shoots in this way, as in the ordinary course of events they would be pruned after flowering.

Continued

POLE AND WIRE WORK

Erecting Telegraph and Telephone Poles and Running the Wires. Insulators. Wire Tables. Ohm-mile Constant

Continued from page 6181

By D. H. KENNEDY

Aerial Lines. Great skill and judgment have to be brought to bear on the construction of aerial telegraph and telephone lines. When a conductor suitable from the point of view of resistance and mechanical strength has been chosen, there remains the mechanical problem of supporting and insulating the conductors at a suitable height to secure freedom from interference and with sufficient strength to meet the static stresses due to the weight of the materials and the kinetic stress due to wind pressure.

The static stress is greatest at the pole where the line begins or ends, usually called the *terminal pole.* There it is the sum of the stresses of the wires; at intermediate poles, where the line is straight, the static stresses due to the wires on each side may balance each other, and in this case the pole, together with half of the span of wires on each side of it, may be considered as analogous to the mast and sail of a ship; the wind presses on the side of the wires as on the side of the sail, and if the pole is not sufficiently strong it will snap off at the bottom as does many a good mast. For this simplest case, then, we need to know something about wind pressure.

Wind Pressure. Wind pressure varies as the square of the velocity. A brisk wind of 20 miles an hour exerts a pressure of 1·08 lb. per square foot. A very high wind of 40 miles per hour gives 4·32 lb. per square foot; 70 miles an hour gives over 17 lb. per square foot; while a hurricane may attain a velocity of 100 miles per hour and a pressure of over 32 lb. per square foot. Standard practice has decided that lines should be built to resist a maximum pressure of 17 lb. per square foot. Next, we must ascertain the dimensions of the resisting surface. As the wires are circular, the effective area is taken as two-thirds of the diameter into the length. A simple calculation will, therefore, give the horizontal stress due to wind pressure. But this is at the height of the wires. To find the moment of pressure at the ground line, we must multiply by the distance between the centre of the wires and the ground line. The result is usually expressed in foot-cwts. This tells us, then, the stress which will act upon our pole at the ground line. The engineer is provided with a table in which the breaking stress in cwts. for various thicknesses of poles is recorded, and he might now obtain from this list the dimensions of a pole which would give the required strength. Where wooden poles are concerned, however, the possibility of a particular sample being much below the average has to be borne in mind, and in this case, as in all similar engineering designs, it is necessary to introduce a factor which shall make for safety; and is, indeed, always referred to as the *factor of safety.* For poles and supports this factor is taken as 8; so that before selecting from his list, the engineer would multiply the "foot-cwts." result by 8. For poles at angle points allowance must be made for the increased static stress.

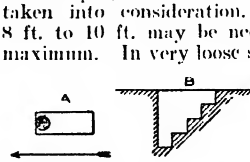
Selection of Route. The erection of a line is preceded by careful surveys in which the relative advantages of different routes are considered and that one is chosen which combines most of the following advantages:

Shortness, so as to reduce the cost;
Straight rather than tortuous roads;
Ease of access for building and subsequent maintenance;
And freedom from difficulties as to wayleaves.

During the progress of the detailed survey all information for the guidance of the foreman who will erect the line is carefully tabulated, positions being chosen for the poles so as to avoid causing obstruction to the public and danger from passing vehicles. They must also be chosen so that the wires shall not hang longitudinally over the carriageway, and poles should be placed so that if the wires fall, they will fall clear of traffic. Road crossings should, as far as possible, be avoided, and on hilly roads the heights of the poles are adjusted as far as possible, so as to avoid abrupt differences in the level of the wires.

Poles. Wooden poles are most largely used in this country, but the use of iron poles is gradually increasing, in spite of their heavy cost. Wooden poles are preserved from rot by creosoting; 10 lb. to 12 lb. of creosote per cubic foot is injected into the pole. Poles so treated have very long lives. They cannot, however, be painted, and where this is required, the process of burnettising, which consists in injecting a solution of chloride of zinc into the pole, is used. Creosoted poles having lengths up to 85 ft. and diameters up to 20 in. can be obtained. For light lines the poles are placed at 70-yard intervals where provision is made for up to eight wires, but for cases where only one or two wires will be needed the poles may be spaced 80 yards apart. For heavy lines 66 yards is the usual interval.

Hole Digging. The hole for the poles should be dug in the direction of the wires. As little ground as possible should be disturbed. It should be arranged so that the pole will stand at one end and this end should be cut down perpendicularly [29]. For ordinary lengths 4 ft. to 6 ft. is the usual depth, but the character of the soil must be taken into consideration. For very long poles 8 ft. to 10 ft. may be necessary, but this is the maximum. In very loose soil or running sand it is sometimes necessary to use concrete. The poles should be set so as to bear against the stress of the wires. In returning the earth to the hole great care must be taken that the soil is thoroughly punned in, and on completion, the soil of the roadway should be returned, as far as possible, to its original condition.



29. HOLE FOR POLE

The height of the pole should be such that on country roads the lowest wire is not less than 12 ft. from the ground: in crossing roads this must be increased to 20 ft., while in towns a height of 30 ft. is necessary.

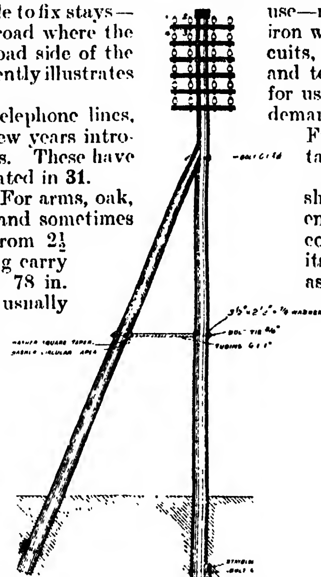
Iron poles are made of 11 ft. parallel lengths with 16 ft. tapering lengths, and the bottom fits into a cast-iron base, which gives a good hold in soft ground. A concrete foundation is usually provided, so that the pole may be secured by bolts let into the concrete. The parts of the pole are put together on the ground.

Stays. The strength of a line is enormously increased by a proper discrimination in providing stays at suitable points. Stays are usually made of iron wire, and they are arranged so that the upper end is attached as nearly as possible at the resultant point where all the forces acting upon the pole can be balanced by an opposing force. They are, therefore, specially suitable at angle points. The lower end of the stay is connected to an iron rod fitted with a stay tightener, and the further end of this rod is passed through a wooden block, usually a 2-ft. length of old pole. The hole for the stay block is usually arranged so that the block is placed in an undercut space and fits against the solid earth. Where it is impracticable to fix stays—as, for instance, at an angle in the road where the stay would have to be put on the road side of the pole—struts are used, and **30** sufficiently illustrates their application.

For the heaviest class of trunk telephone lines, the Post Office has within the last few years introduced a system of trussed " H " poles. These have given splendid results and are illustrated in **31**.

Pole Arms and Fittings. For arms, oak, well-seasoned, is usually employed, and sometimes Karri wood. The sections vary from $2\frac{1}{2}$ in. to 3 in. square. Arms 48 in. long carry four insulators, and lengths up to 78 in. are in common use. Arms are usually spaced 12 in. apart from centre to centre, and this distance also obtains between the respective insulators.

Poles are always provided with an iron wire, which is arranged to act as a lightning conductor, and is stapled down the side of the pole and terminated in one or two coils stapled round the bottom of the butt. The main purpose of this provision is, however, to prevent what is called "weather contact." In wet weather a film of moisture bridges the distance between the adjacent wires, and current would leak from one circuit to another. The " earth wire " provides, however, an alternative path. The arms are also earth wired. It will be seen that the loss of current per circuit is thus slightly increased, but interference is averted.



30. POLE WITH STRUT

Pole Roof. The top of the pole is usually cut obliquely, coated with a mixture of coal-tar, creosoted, and provided with a galvanised iron roof. In towns ornamental pole finals are used. When the fitting of the pole with roof, earth wire, arms, and, in some cases, galvanised iron steps, has been completed, it is erected by pushing the butt into the hole, so that the butt end comes easily into the place it will finally occupy. The stepped end of the hole acts as a fulcrum in such a way that the weight of the butt assists in lifting the top, and the pole is gradually raised to the vertical position at first by hand, and subsequently by ladders, half a dozen men being usually employed. Even for the heaviest poles, ten men are quite sufficient where the foreman exhibits proper generalship. The presence of too many men is apt to be a source of danger, and a proper understanding between those concerned in the work is of the utmost importance.

Insulators. The standard pattern insulator used in England is made of white porcelain, screwed so as to fit on a screwed steel spindle, and provided with two petticoats [**32**]. For short lines, where a very high standard of insulation is not necessary, brown earthenware made in the same pattern is frequently used. In fixing the insulator an india-rubber washer is inserted between it and the shoulder of the spindle to allow for differential expansion. The insulators are put into position after the pole has been erected, the steel spindles being securely bolted to the arms. It is interesting to note that in America glass insulators are used instead of porcelain, and wooden (locust) pins instead of steel spindles. At terminal poles, where the pull is all on one side, J-shaped spindles are used, fixed to the under-side of the pole, and arranged so that the pull of the wire comes opposite the centre of the arm.

Wire. Three classes of conductor are in general use—namely, iron, copper, and bronze—iron wire for unimportant telegraph circuits, copper for important telegraph and telephone circuits, and bronze wire for use in towns where irregular spans demand increased mechanical strength. Full particulars are given in the table below.

Ohm-mile Constant. This should be carefully memorised. It enables the resistance per mile of any conductor, which may be named by its weight per mile, to be at once ascertained. Thus, if 70 lb. bronze is referred to, $\frac{1,820}{70} = 26$, which is the resistance in ohms per mile.

Erection of Wire. The effects of temperature have a most important bearing upon the erection of aerial wires. It is clear that if wires are erected in hot summer weather, when winter approaches, owing to the decrease in temperature, they will gradually shorten, and if sufficient allowance is not made for this, it is possible that the limit of elasticity may be passed and the wires ultimately broken Arrangements are therefore

PARTICULARS OF CONDUCTORS

Weight per mile (lb.) standard.	Approximate standard wire gauge.	Diameter (mils) standard.	Resistance in standard ohms per mile at 60° F. of standard size.	Minimum breaking stress (lb.).	Ohm-mile constant resistance by weight.
		IRON WIRE			
400	7–1/2	171	13·32	1,240	5328
200	10–1/2	121	26·64	620	
60	16	66	88·8	—	
		HARD DRAWN COPPER WIRE			
800	4–1/2	224	1·098	2,400	878
600	6	194	1·464	1,800	
400	8	158	2·195	1,250	
300	9–1/2	137	2·928	950	
200	11–1/2	112	4·391	650	
150	13	97	5·855	490	
100	14	79	8·782	330	
*181	7/19	†(40)	4·86	580	
*112	3/18	†(48)	7·87	350	
		BRONZE WIRE			
150	13	97	12·14	730	1820
70	16	66	26·	345	
40	18	50	45·5	197	

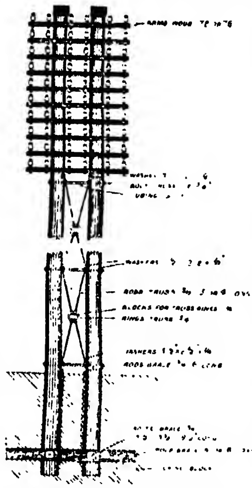
* Strand. † Diameter per strand.

made, so that the stress to which the wires are pulled up on erection is arranged with reference to the temperature in such a way that should a winter temperature of 22° F. occur, the stress will then be at the maximum allowed—namely, one-fourth of the breaking stress. This is another way of saying that wires are erected with a factor of safety of 4 for low winter temperature, and that at all other times the factor of safety is higher than 4. To secure this state of affairs, tables showing the stresses for various lengths of span corresponding to different temperatures are prepared for all classes of conductors, and supplied to the wiremen, who are also supplied with thermometers. Owing to their differing temperature coefficients, dissimilar conductors are never, if it can be avoided, erected on the same pole route. For bronze, a factor of safety of 3 instead of 4 is employed.

Twisted Wires. For the purpose of eliminating inductive disturbance in metallic telephone circuits, it is necessary to arrange the two wires which form a loop in such a way that their average distance from all disturbance is the same. This condition is attained in England by causing the wires to revolve round each other. Four wires forming two telephone circuits are taken together, and arranged so that they form a square on, say, the left side of the pole on the top two arms [30]. These are numbered as follows:

No. 1.—Top outside.
No. 2.—Top inside.
No. 3.—Bottom inside.
No. 4.—Bottom outside.

At the next pole the wires from No. 1 position will shift to No. 2 position, the No. 2 wire to No. 3, and so on, and this process is continued, so that on the fifth pole the wires come back to the same position that they occupy on the first, having completed one revolution. If, now, a single-wire telegraph circuit is sending out disturbing electro-magnetic waves, the inductive effect on one wire of the telephone circuit will be balanced by the equal and opposite effect of the other, and the disturbance will be completely eliminated. Here, again, a curious difference exists between English and American practice. In America it is preferred to run the wires straight on the arms, introducing, however, crosses at frequent intervals on what are known as "transposition poles."

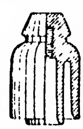


31. POLE FOR HEAVY TRUNK LINES

Joints. The connections between successive lengths of wire are made by means of the Britannia joint. The ends of the two lengths of wire are cut off and laid side by side for about 2 in., binding wire is then wrapped round the conductors over the whole of the over-lap portions, and with a few turns on the single conductor at each end: 50 lb. tinned copper wire is used for copper conductors, and 60 lb. galvanised iron for iron conductors. A flux is then applied, and the joint rapidly soldered, overheating being carefully avoided and the joint being allowed to cool naturally. In order to prevent electrolytic action, the joint is subsequently black varnished.

Wire Running and Binding-in. In order to pay out the wire uniformly, and for the purpose of avoiding kinks, a rotating drum is employed. A long length of wire is run out sufficient for eight or ten spans, the wiremen passing it out loosely over the arms at each pole. The wires are first drawn up as tightly as possible by hand, and then by draw tongs. A tension rachet is connected to the draw tongs for the purpose of observing the stress. When the wires have been drawn up to the proper tension they are attached to the insulator. This is done, in the case of iron wire, by using 60 lb. binding wire. This is first lapped round the line wire on one side of the insulator, then taken round the neck of the insulator and lapped round on the other side; two thicknesses of wire are usually employed. For copper wire, a different method is in vogue: the line wire is first served with a sheath of copper tape to protect it from abrasion against the insulator neck; a copper binder, about 20 in. long and having its centre of round copper and its ends flattened out, is then applied; the round part passes round the insulator neck, and the flattened ends are wrapped round the taped conductor, the wrapping being arranged over on one side and under on the other. It need hardly be stated that the stress is greatest at the point of the attachment to the insulator, and that this is where breakages most usually occur.

Maintenance of Aerial Wires. Skill and judgment are as necessary for the maintenance as for the erection of lines such as have been described, and in stormy districts the lives of the engineers and linemen are seldom troubled by monotony. As the number of wires increases, constant vigilance has to be exercised, to eliminate weak spots. The poles have to be examined periodically to see that the normal factor of safety has not been unduly encroached upon. In districts where snow prevails accumulations sometimes take place which transform the wires into white ropes of 3 in. to 4 in. diameter, a result which is usually followed by the practical demolition of the lines, especially where frost and wind follow the accumulations. Trees are often blown by the wind across the lines, and when one span has been broken through, the trouble may run back for a considerable distance, owing to the sudden removal of the balancing stresses. Spans over rivers and ravines have to be negotiated, and in all cases the work of repair has to be done against time, as communication must be restored after the briefest possible interval.



32. INSULATOR

Continued

Group 23

TAXIDERMY

Following
APPLIED BOTANY
from page 6110

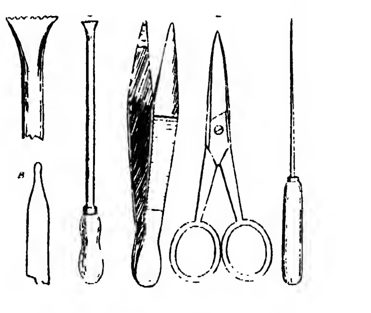
PRACTICAL TAXIDERMY

How to Stuff Birds, Animals, and Fishes. Mounting Horned Heads. Finishing Mounts, Cases, Rockwork and Scenery. Skin Cleaning and Preserving

IN attempting the practice of taxidermy the best subject for a beginner to experiment on is a bird—not too small or delicate—such as the common starling, the feathers of which are not difficult to handle, and the skin fairly tough.

The tools [1] necessary are a sharp-pointed knife—a penknife will do; a pair of strong, pointed scissors; a sharp-pointed awl or pricker; a pair of side-cutting pliers for cutting wire; a pair of tweezers for arranging the feathers; a file, and a needle. We shall also require some cotton-wool and wire; some pins and glass eyes; tow, wood-wool shavings, similar to those used for packing; some strong thread and soft cotton; powdered alum, arsenical soap, fine sawdust, and a little plaster of Paris.

Preparing the Bird. The first operation is to put a thread through the nostrils of the bird, making a knot, and leaving a loop as long as the neck and body of the bird. The loop will be of great assistance in returning the head when the bird is skinned. Plug the nostrils, throat, and any shot holes with wool. If the body is very moist use a little sawdust and plaster of Paris to absorb the blood. Break the wing bones (the humerus) close to the body. Make an incision in the middle of the breast [2], first blowing the feathers apart, and continue the cut to the vent. Care must be taken not to cut too deeply in the abdomen, or the intestines will protrude, and give great trouble by making the feathers dirty: sawdust and plaster should be applied to prevent this. The skin should be pressed back with the side of the knife. No further cutting will be necessary until the tail and the legs are undertaken, when the scissors should be used to snip the tail-bone. The legs should be pushed up, and the first joint exposed must be cut with the knife.



1. TAXIDERMIST'S TOOLS
a. End of stuffing iron *b.* Section of stuffing iron *c.* Complete stuffing iron *d.* Tweezers *e.* Scissors *f.* Pricker *g.* Skinning knife

Remove the flesh from the leg down to where the feathers end, return the leg-bones to the skin, and proceed to press the skin away from the back. Cut through the wings where broken, and turn the skin inside out down to the head, holding the body between finger and thumb. Great care must be taken not to split the skin in getting it over the head. The ears will first be met and cut through; then the eyes, which require still more care. Skin down to the bill [3]. Cut through the base of skull and remove the neck. The brain, tongue and eyes should now be removed and the sawdust and plaster brushed off. Apply alum if the skin is very moist or not quite fresh; anoint all bones and the inside of the skin carefully with the arsenical soap, and place a ball of wool in the orbit of each eye.

Stuffing. Now lay the skin on the table, and return the skull to its proper position; the loop of thread in the nostrils will assist this operation. Coax the skin with finger and thumb over the skull, and the whole skin will, with a little shaking, return to its natural position. Smooth the feathers of the head the right way, and work the body-feathers downwards into position. Now make an egg-shaped body the size of the one taken out, using the wood-wool for this, pressing it together tightly, as the leg wires must depend on it for fixing firmly. Cut a wire twice the length of the neck and body, and point it at both ends. Drive the wire through the body, make a loop, return it, and then clinch it.

Wind a little tow round the wire to form the neck, being careful not to make it longer than the one taken out; and drive the wire through the centre of the skull and work the skin down over the body. Cut two wires three times as long as the legs, point at one end, and insert one underneath each foot, working it up the back of the leg; a little tow must be wound round the wire and bone to make up the flesh removed from the thigh-bone. The wire is now driven through the body, out under the opposite wing, turned, and pulled back into the body. A slit must be cut in the skin to allow the loop to pass and so leave the skin free. Insert a little pad of tow in the base of the tail, and sew up the skin, taking care not to sew down any feathers. The legs should be bent into their natural position.

Mounting. The bird has now to be fixed on a twig or a perch. Two holes are bored through the perch to take the leg wires, and the wires are twisted firmly to the perch. The tail must now be adjusted, one, and sometimes two pointed wires being used to fix it in position. The wings require two wires each, one through the shoulder, the other near the roots of the primaries or quill feathers. Fix both wings the same height or the bird will appear lopsided when completed.

The throat may be filled out from the mouth with tow, finely chopped with scissors, and the cheeks filled from the eye. The eyes are then inserted, and the tail expanded to the required width between two slips of cardboard.

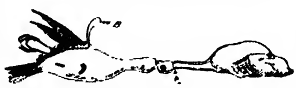
The final binding with cotton is next, a long pin being inserted in the back, and one or two in the breast, keeping to the centre line of the body. The pins, with the four long wires, and the wire protruding from the head, are utilised in winding the cotton round the bird to compress the feathers gently into place while the bird is drying [4]. The novice must not expect his first bird to be a great success, or perhaps his sixth or twelfth, for, simple as the operation may seem, it requires practice to get the natural shape and pose.

Animal Stuffing. Small animals up to the size of a rabbit will require the same tools and

materials as those required for mounting small birds. Before skinning, an outline of the animal should be made by laying it on a sheet of brown paper in as near the position as possible in which it is intended to mount it, and its shape marked with a long pencil or crayon, the size of the body being marked on this sketched outline.

Always skin an animal down to the toes. The tails in small animals can be drawn without cutting them open. The lips must be split, and moist clay inserted to give them fulness. The ears must be skinned and clay used to replace any flesh taken away; sheet zinc, cut to the proper shape, is used to stiffen and keep them in position. Always keep the leg bones on the skin, as they are invaluable in shaping and posing the animal.

2. BIRDSTUFFING: THE FIRST INCISION
Thread loop tying up beak

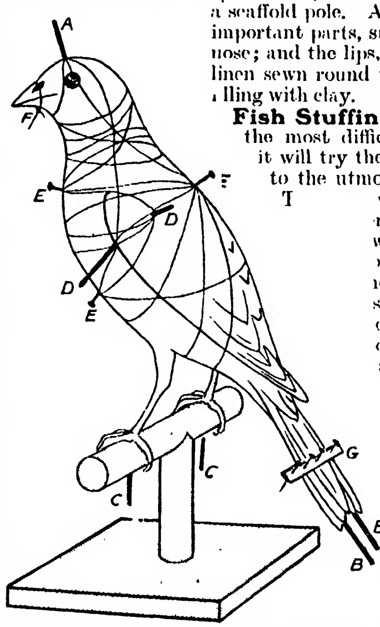


3. BIRDSTUFFING: SKIN TURNED INSIDE OUT
a. Point to cut head from neck *b.* Thread loop to assist in returning the skin

The hard, egg-shaped body used in bird-stuffing is not used for stuffing animals. The head and body wire is twisted tightly in with the fore legs first, then the hind legs. The length of wire used must allow for fixing the animal upon the stand.

The neck and body are gradually filled with chopped tow, wood-wool, and sometimes with hay, keeping the shape and ultimate position in view. Never use tow without chopping it up small, or it will form an immovable ball inside the skin, and show an ugly lump; cotton-wool, also, should be avoided for the same reason. Soft pipeclay is very valuable in the head, feet, and those parts where such details as muscles must be shown. Always use annealed iron wire, thick enough to give stability, and bear in mind that it is easier to add a little stuffing than it is to get it out.

The hair must be cleaned and brushed and combed in its natural direction while the specimen is wet; blood and grease must be washed out before stuffing. Fat left on the inside of the skin prevents any preservative acting properly, and will cause the skin to rot. It is better to allow the skin to remain a few hours for the alum to act on it before applying the arsenical soap. The action of alum is astringent, shrinking the skin and so fixing the hair firmly by the roots; it will also extract the surplus moisture from the skin, but any crystals remaining undissolved are better brushed off before applying the arsenical soap. The eyes, ears, lips, and toes require special attention, to see that the alum is worked in well. If the skin cannot be stuffed immediately, do not let it remain folded on itself; place a little hay or tow inside it to prevent the inner surfaces touching. If this is not done, the skin will sweat, decompose, and the hair will fall off at the slightest touch. The leg bones must also be wound round with tow.



4. STUFFED BIRD READY FOR DRYING
a. Head, neck and body wire *b.* Tail wires *c.* Leg wires *d.* Wing wires *e.* Pins to keep cotton in position *f.* Thread to fasten beak *g.* Cardboard slips to hold tail feathers

Larger Animals. The larger animals require a different treatment: the legs in animals the size of deer and larger must be opened right down the inner side, so that the seam is least noticed when mounted. The irons for the legs will require to be tapped, and two nuts fitted to each leg, to give the support to carry the weight when fixed up. The irons must be bent to the proper curves and angles, which the paper outline will give. A board, about 2 in. thick, must be cut to the shape and size of the body. The leg irons are very firmly fixed to the board by iron staples, as also is the iron for the head and tail. The head iron is brought through the skull by passing it through the nostrils, and is cut to its proper length when the head is finished [5].

The bulk of the body is made up by fixing dry straw to the body board. It must be tied securely round the board with string, shaped as nearly as possible to the pattern and measurements, and made a little under the proper size [6]. The skin may now be tried on, and if the edges meet comfortably, and the legs are the right length, the skin may be sewn up. Begin sewing at the neck and work downwards.

The dried skins of the larger animals are very stubborn, and require to be pared down with a spokeshave, the skin being laid on a short length of a scaffold pole. A knife must be used for the more important parts, such as the ears, the eyes, and the nose; and the lips, if they cannot be split, must have linen sewn round the edges to form the pocket for filling with clay.

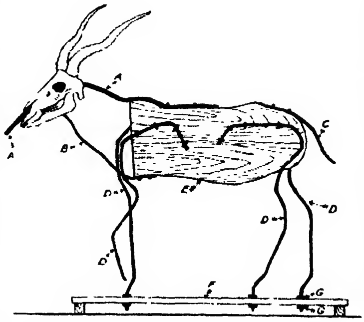
Fish Stuffing. The stuffing of fishes is one of the most difficult branches of taxidermy, and it will try the patience and skill of the novice to the utmost.

T water perch is a good species to nt with. Choose the best side for w side, and mark its outline on a f paper as a guide. Make a cut e other side with a strong pair of sors, down the middle of the dy from the centre of the gill over to the root of the tail. Use a knife to free the skin from the flesh, and cut from tail to head.

The skin of a scaly fish must not be turned, as in birds and animals, or the scales will be disturbed. The root of the tail and fins must be cut with the scissors inside the skin. See that the points of the scissors do not cut the skin, or a few scales will drop out. The gills and all the bones of the head must be cut away with the scissors. When the skin is ready, it must be soaked in water to remove any blood and slime that may adhere to it. All loose scales should be saved, as they will, perhaps, be wanted for repairing the skin.

There are several methods of stuffing fish, and one of the simplest of them can be used for fish up to the weight of 5 lb. Take fine yellow sea-sand, damp it so that it is just tenacious enough to retain a

shape when grasped by the handful. After using arsenical soap on the skin (alum should not be used for fish), sew up the skin a few inches at the head, and also at the tail. Place a loose ball of tow in the mouth to keep the sand from coming out, and fill the skin with the wet sand, pressing it tight and modelling the shape as the filling proceeds. Finish the filling in the middle of the body and sew it up. The fish must now be turned over on a board a little longer and wider than itself on which it is to lie and dry. Pat the head into shape, and work the body downwards to its proper curve. Fish skins always tend to become longer, and this must be prevented, or the result will be a failure. The fins and tail must be extended and fixed between two pieces of cardboard, pins being used for fixing them. The fins and tail must not be allowed to dry during stuffing, as in this state they are very brittle, and cannot be extended properly.

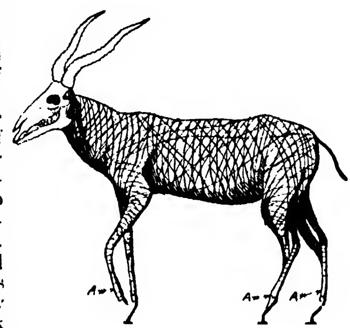


5. ERECTION FRAME FOR AN ANTELOPE
a. Head iron b. Neck iron c. Tail iron d. Leg irons e. Body wood f. Temporary stand g. Leg iron nuts

When the fish is properly fixed, a thin coat of gelatine, melted in warm water, will keep the scales in position. The fish must now be placed on a warm shelf to dry slowly, and examined occasionally to see that it is drying smoothly.

When the fish is dry, remove the sand by opening the seam and gently tapping the body. It is then filled with tow, wood-wool, etc., and the seam glued together and covered by a strip of linen. A small wooden block to which are fixed two wires is also glued on the seam for fixing up the fish in a case. The finishing and colouring of fish require much practice, and it is easy to overdo the colour. Use whenever possible transparent oil colours and a clear "crystal" varnish. The belly colour is the most important point to get right. It is usually white, and is shaded very gradually to the colour of the sides.

The eyes must be of the same size as in nature: the orbit of the dried fish is always larger than in nature, through shrinkage, so it must be filled up to its proper size with a composition to be described hereafter.



6. MANNIKIN READY FOR SKIN
a. Artificial leg bones of wood

Mounting Animal Heads. If the animal has horns, it must be skinned by having a cut made up the back of the neck until it is level with the base of the horns, when a T-shaped cut must be made up to each horn, and continued round the bases to free the skin, so that the skull comes away entirely from the skin [8]. Remove the flesh from the skull, which must be boiled until thoroughly clean, and when it is dried it will be ready to mount inside the skin. The skin is rubbed, first with alum, and then with arsenical soap, and the ears fitted with zinc and clay.

Heads are fitted up differently from those of animals stuffed entire. Thick wood takes the place of iron for the support, and a piece of quartering, longer than the neck, is fixed in the skull, and several long screws driven at right angles through the bone into the wood. Cut a board not less than 1 in. thick, nearly the shape of an elongated egg, and trim off all sharp edges smoothly. This is called the back-board, and must correspond with the size of a cross-section of the neck at its extremity [8]. The quartering, having been fixed in the skull, must be cut to the length of the neck. The neck should be as long as the skin will permit; short necks look very bad, and an animal stuffed with a long neck can be made to look much more lifelike.

The skull, as at present fixed, should be hung on a wall, to find if the quartering is cut to the proper angle, so that the neck may be given a graceful curve. If there are horns in the specimen, the points can be brought to within 2 in. of the wall with safety. Horns do not always grow evenly, but it is possible to rectify this slightly while fixing up the skull. When everything is satisfactory, wood-wool is bound round the quartering to the shape of the neck [9], the skin is fitted on, and sewn up. Begin the sewing at the horns, and work down to the back-board; any stuffing which the neck requires must be inserted before the skin is fixed to the back-board. Three-quarter inch French nails are the best to use for fixing the skin, as in drying the skin strains very much, and would pull shorter nails out. The cheeks are stuffed from the mouth and eyes, and the head finished as in entire specimens, plenty of clay being used in modelling the eyes, nose, and mouth. The glass eyes should be put in after the skin has dried, on account of the shrinkage during drying.

The shrinking of the skin is the bane of the taxidermist. The chief causes of shrinking are insufficient paring down of the skin, using clay too wet, stuffing the specimen too loosely, and not fixing and sewing up the skin tightly.

Before colouring the eyes, nose, and mouth, the specimen must be cleaned and beaten thoroughly. White French polish and methylated spirit in equal parts, and dry powder colours, are the best materials for colouring. Use stiff hog-hair brushes to work the colour in, and do not forget that the colour will, when dry, be half as light again when the spirit evaporates, which it does quickly. A little varnish will be required on portions which in nature are wet, such as eyelids, nostrils, open mouths, and lips. The horns are cleaned with soda-water, and rubbed with linseed oil and turpentine, to darken them.

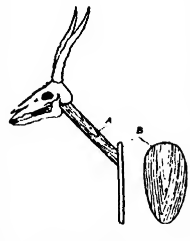
Finishing and Casing. Cases should not be cramped, plenty of room being allowed for rock-work, glasses, and fittings, in order that they may be displayed in a natural way.

The case had best be made by a cabinetmaker: the wood used mostly is deal. Insist on having the best material and workmanship, as a faulty case will spoil everything. Panel backs to all cases are best, as splits in the wood are thus avoided. The

back is lined with calico, carefully stretched and fixed with glue and tacks. When this is dry, paste white lining paper evenly over the calico. All the woodwork which is inside, except the bottom, must be coated with size mixed with powdered red lead; if this is not used the resinous matter and knots of the wood will show through the paper and make ugly spots. The inside of the case should be coloured with water colours, and a landscape may be represented.

Rockwork. Rockwork is made with brown paper supported with wood, and in large work the basis is canvas, covered with paper wetted with warm water, and laid on evenly with glue. Considerable taste and practice are required to get the appropriate angles and curves to imitate different forms of rock.

When the glue is dry, the basis is quite stiff enough. Melt some size by adding one-fourth its bulk of water, add slowly to it crushed whiting until it has the consistency of gruel; apply this *hot* to the prepared basis. Have some dry sand, yellow or silver, according to the rock you wish to represent, heated to a temperature comfortable to handle, and throw it forcibly on the hot composition. When cold gently knock the rockwork, and all sand which has not adhered will fall off. Colours ground in oil will do for colouring the rockwork. Do not overdo the colours—follow Nature in every way.

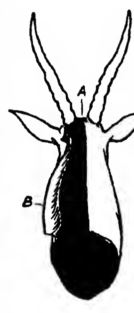


7. WOODWORK FOR GAZELLE HEAD
a. Quartering fixed in skull *b.* Back-board

Grasses, ferns, rushes, and boughs must be thoroughly dry before using, and may be coloured with oil colours to which a very little varnish is added. Avoid stiffness; everything should look as if it were growing. This portion of the work is one which requires and deserves as much time as possible to be devoted to it.

The glass should be cut to fit the case exactly and fixed by strips of wet paper of the same colour as the case. Black is by far the best colour to show up most subjects. The paper is applied with very smooth paste made from ordinary flour. As the paper shrinks in drying, it gives a stronger fixing.

Cleaning Skins. Fresh blood can be removed easily by washing the blood patch with warm water of a temperature not above blood heat, in which is dissolved a little of Hudson's Extract of Soap. If a bird is the subject, never allow the feathers to be wet longer than is absolutely necessary, and extract as much moisture as possible with a dry duster. Then saturate the feathers with benzoline, sprinkle plaster of Paris over them, beat the plaster off again at once, and repeat the process, using fresh plaster and adding more benzoline until the feathers appear dry.



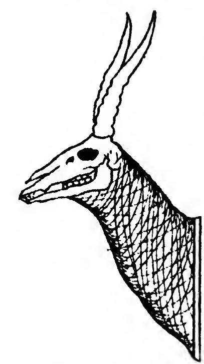
8. SKINNING A HEAD
a. Cross cut *b.* Skin partly removed *c.* Shape of cut

Benzoline is a solvent of grease; it also forces out the water contained in the feathers and prevents the plaster from setting, but quick beating is required when the first plaster is applied. The plaster absorbs the grease dissolved by the benzoline and also cleans the feathers; but the skins must be thoroughly beaten to get the plaster off. If the skin has no blood on it, the soap-powder and water will not be required and much time will be saved. This recipe will also answer for the treatment of small and large animal skins.

The composition for stopping up and repairing holes is made by mixing melted glue and well ground whiting to the consistency of stiff dough; the amount of glue must be determined by testing the composition with the fingers. It should feel tacky and stick to the finger; if it crumbles add more glue. When worked well together, add one tablespoonful of boiled oil for every pound of glue used and knead the constituents until they are thoroughly mixed. The composition can be used after it has become cold and hard by steaming.

In fixing artificial eyes, modelling nostrils, lips, tongues, and the innumerable requirements of taxidermy, this composition is used. It can be made to imitate any surface by manipulating it properly, and is easily coloured.

Arsenical Soap. This is made of 3 lb. white curd soap, 3 lb. arsenic powder, and 8 oz. camphor. Slice up the soap and melt over a fire in as much water as will just cover it, and stir well to keep it from burning. Crush the camphor very small with a little methylated spirit and add this, together with the arsenic powder. The whole should form a creamy paste. Arsenical soap has been decried by some taxidermists, but it still holds its place with the trade, and will do so until a better preservative is found.



9. GAZELLE HEAD
Ready for skin to be fitted on

Treatment of Skins for Storing. Animals' skins are sometimes found infested with a pernicious insect (Dermestes) the grub of a small beetle. It is the most destructive insect with which the taxidermist has to contend. It eats through the toughest skins and it has been known to eat through cork. When this pest is found in any specimen, instantly saturate everything in the same case or box with turpentine, and keep the case closed for a short time.

Naphthaline crystals are very good to use in boxes of specimens of all kinds. Cyanide of potassium is a dangerous poison, but a powerful insecticide if placed in boxes of skins; it should be enclosed in a block of plaster of Paris, the cyanide being placed in the plaster before it has quite set. If it is not enclosed in plaster, the chemical will absorb moisture, and run on to the skins with which it is in contact and spoil them.

TAXIDERMY *concluded; followed by* BACTERIOLOGY

Group 11
CIVIL ENGINEERING
44

HARBOURS AND DOCKS
continued from page 6220

HARBOUR CONSTRUCTION

General Construction of Several British and Foreign Harbours. Natural Harbours. Breakwaters

By A. T. WALMISLEY

Dublin Harbour. This is a type of the jetty harbour, with jetties converging towards the entrance. The river Liffey forms the channel of the harbour, dividing the flat, sandy beach into two strands, called the North and South Bulls. The tendency of the sandy deposit from the sea was to form a continuous strand all across the western shore of the bay, which was only partially prevented by the tidal flow in the river, and the result was a bar at its outlet. The outlet channel of the river was regulated by the construction of a rubble embankment along its southern side, called the Great South Wall, completed in 1796, which served to protect the channel in south-westerly gales, and prevented the inroad of sand from the South Bull, but no improvement resulted owing to the absence of scouring power in the river. The North Wall was constructed from 1820 to 1825 in order to deepen the channel across the bar. This wall was raised to only half-tide level along its outer portion, so as to allow the earlier half of the ebbing current to flow over it, this portion of the current possessing little scouring effect. The construction of these solid jetties—3¼ miles and 1¾ miles in length respectively—gradually lowered the bar from 6 ft. below low water in 1819, to 16 ft. in 1880, this result having been aided by dredging in the inner channel, and by the removal of ballast from the north strand within the northern jetty.

Sunderland Harbour. The outlet of the old entrance to the port of Sunderland was originally guided by parallel jetties across the sandy beach, but when docks were constructed, a new southern outlet with converging piers was provided, affording a better depth of water. As the chief littoral drift comes from the north, the entrance has been made to face south-east. The plan of the outer harbour is specially favourable for stilling the entering waves, and gives easy access to the two dock entrances; it also affords ample area for dredging. The docks and outer harbour form artificial sluicing basins, which concentrate their scouring current through the narrow entrance.

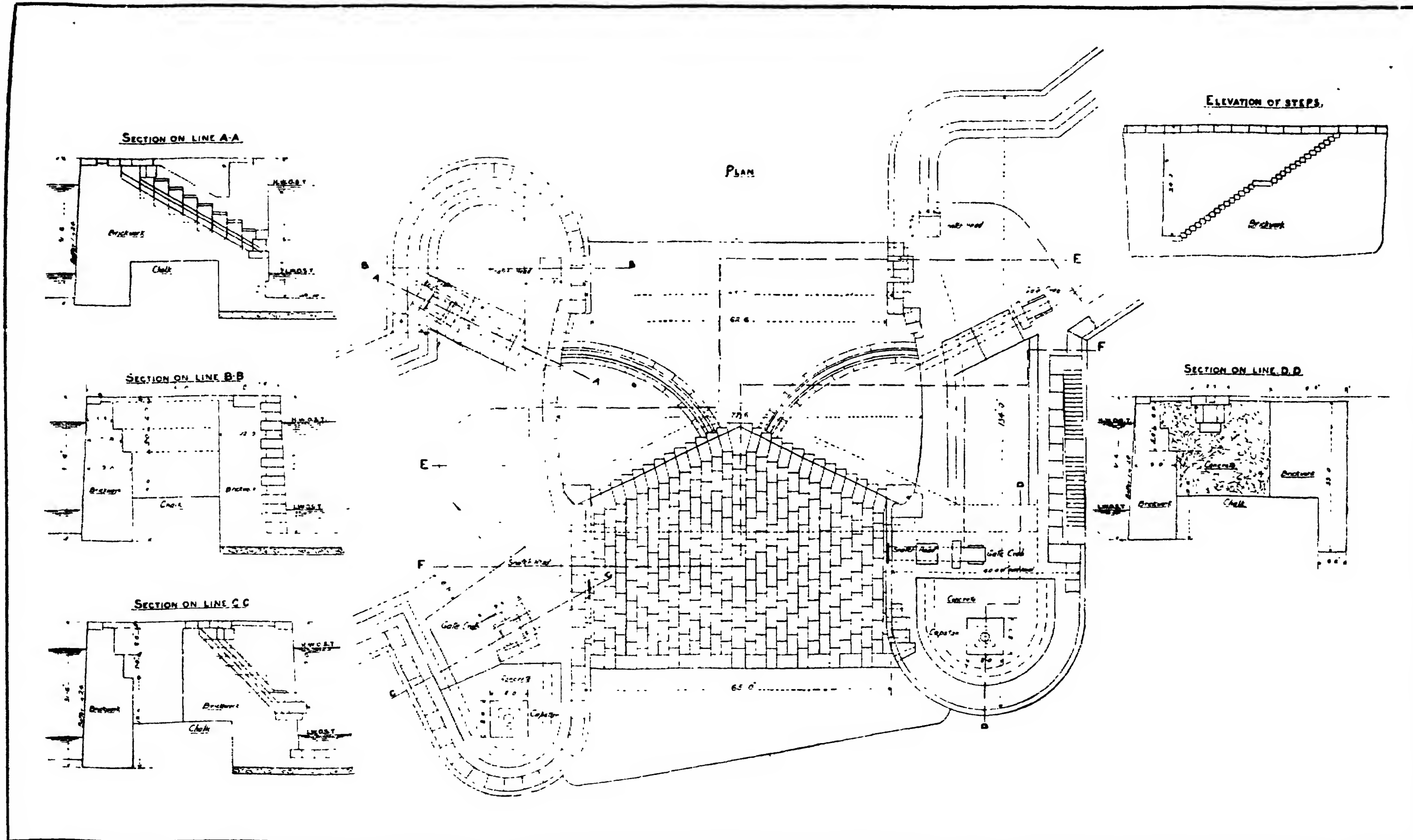
Aberdeen Harbour. This harbour consisted originally of the natural channel of the River Dee at its outlet into the North Sea. During north-easterly gales a channel over the sandy beach could be maintained only with difficulty by the tidal waters, and a bar existed at the mouth of the river. The north pier was constructed about the year 1773 to a distance of about 1,200 ft. from high-water mark, with the object of stopping the drift of sand along the shore from the north, or of carrying it out to such a distance that the main tidal current would convey it away, thus removing the bar. The scour produced by this work and by a southern pier, which was constructed parallel to the river on the opposite side, maintained a depth of about 2½ ft. over the bar at low-water spring tides. In order to provide a large harbour with better shelter, new works were carried out consisting of a southern breakwater and north pier extension. The southern breakwater was completed in 1873, and the north pier extension in 1877. The construction of both was concrete on the upright wall system, and both are somewhat similar in section. The works have so far accomplished the objects for which they were designed, in having provided a large harbour sheltered from south-easterly gales and in giving a wide entrance (1,100 ft.) between the pier-heads in a depth of about 15 ft. at low-water ordinary spring tides. The bar which formerly existed has been kept down by dredging during the summer months.

Parallel jetty harbours have not proved universally successful in the North Sea and in the English Channel for providing a deep entrance without constant works of maintenance. Silt generally accumulates outside the jetties from the pier-heads to deep water, and consequently dredging is required here. Parallel jetty harbours are among the most difficult class of harbours to design and maintain successfully, but the construction of sluicing basins, and the development of dredging plant tend to improve their condition considerably.

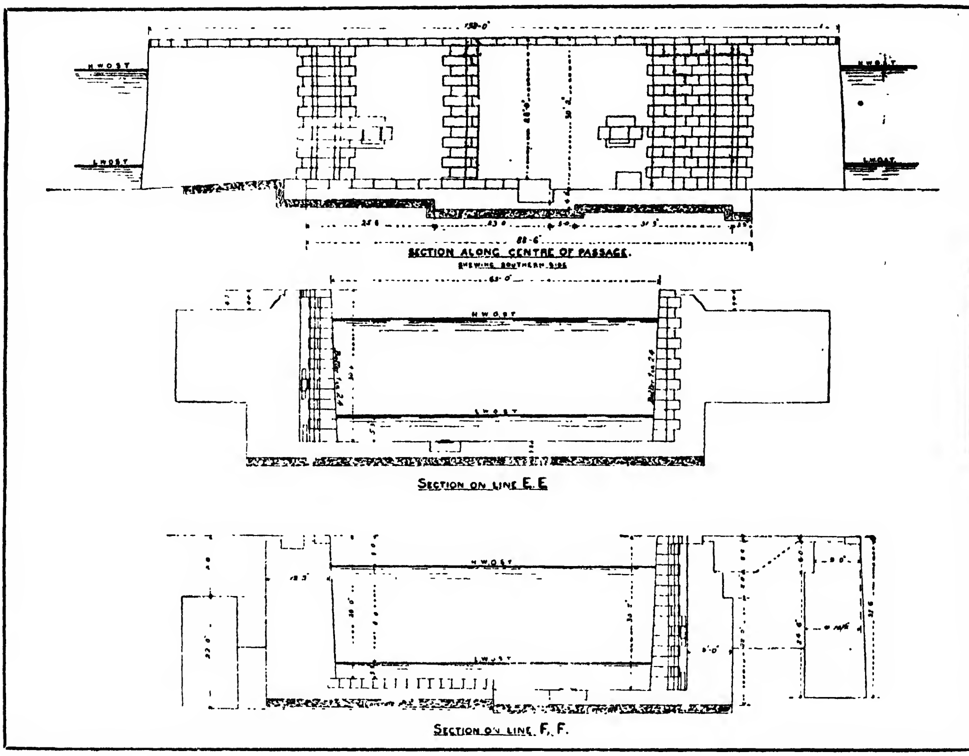
Lowestoft and Ostend Harbours. Lowestoft Harbour was originally formed by cutting a channel from a low-lying marsh, called Lake Lothing, to the sea, and parallel wooden jetties were carried out across the beach, on each side of the channel, to a depth of 12 ft. at low water spring tides, but it was found that the scour produced in the channel by the ebbing of the tide from Lake Lothing, was not powerful enough to contend effectually against the drift of sand and shingle from the north across the entrance, and consequently a bar was formed. Subsequently additions were made to the harbour by building piers on each side of the old entrance channel. The harbour authorities have had to resort to dredging from time to time in order to maintain a sufficient depth of water.

The peculiarities of the site of Ostend, where open jetties control the harbour entrance, lie in the fact that as the coast-line projects, the sea tends to encroach rather than to recede, so that the foreshore has not advanced like other jetty harbours. Groynes formed along the beach to the west of the harbour protect the shore. The jetties cannot be lengthened to reach deep water owing to the "Stroom-bank," which extends in front of the entrance at a short distance from the shore, and the navigable channel is between this bank and the end of the west pier-head. Though a regular mail service has existed for many years between Ostend and Dover, the bar has at times hindered the entrance and exit of the steamers. The sluicing basin near the entrance to the harbour has helped to maintain the necessary depth of water for the passage of the mail steamers, but the development of modern dredging plant has helped to minimise this trouble.

Dieppe and Boulogne Harbours. The entrance channel at Dieppe harbour is guided and protected by parallel jetties. It has a sluicing



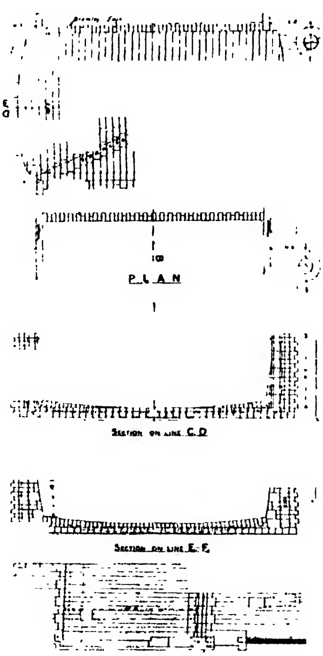
1. GRANVILLE DOCK, DOVER HARBOUR



2. SECTIONAL DETAILS OF GRANVILLE DOCK, DOVER HARBOUR

basin for maintaining the depth of the channel. The outer, or tidal harbour, gives access to the various basins, which are entered through locks, provided with gates for maintaining a high-water level. Solid masonry quays line the inner portion of the jetty channel, except for a portion where there is an open jetty of ironwork which communicates with a stilling basin for reducing the swell following the concave side of the channel. Open jetties are constructed along the outer portion of the channel near the pier-heads, with stilling basins behind for receiving the entering waves, the older western jetty being made of timber. Shingle travelling along the coast used to obstruct the channel to a certain extent, by passing round the west jetty and settling along its inner face, but was removed temporarily by the sluicing current. This travel of shingle has been partially arrested by a series of groynes constructed along the shore to the west.

The south-west jetty at Boulogne is built of masonry up to high-water spring tides, with a superstructure of open timber work, and extends out



3. WELLINGTON DOCK, DOVER HARBOUR

beyond the other to facilitate the entrance of vessels. The north-east jetty is solid along the inner portion and consists of open timber-work for the outer 1,000 ft.

A sluicing basin, having an area of 163 acres, maintained the channel between the jetties at a depth of $5\frac{1}{2}$ ft. below low-water spring tides, but the bar beyond the pier-heads was sometimes a foot above low water. Dredging by means of sand pumps had to be resorted to for improving the depth. The south-west jetty has been extended and two additional jetties constructed, so as to enclose the old jetty harbour. Two entrances are provided facing north and west respectively, 820 ft. and 490 ft. wide. Docks and quays have been constructed within the area, sheltered by the breakwaters. The breakwaters consist of a solid superstructure of masonry resting at low-water level upon a mound of rubble with concrete blocks to protect the sea slope.

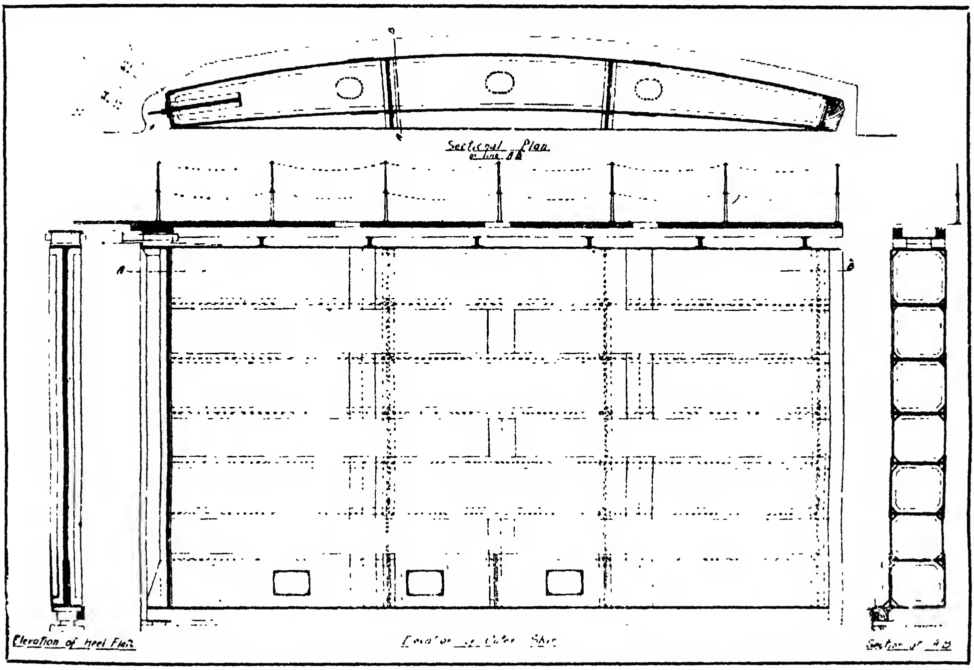
Calais Harbour. The jetties forming the entrance to Calais harbour consist of open timber-work resting upon a foundation of pitching and

fascines carried up slightly above the level of the beach, to allow of the free flow of the currents, but preventing the inroad of sand into the channel. The inner portions of the jetties are constructed with masonry up to high-water level. The width of the entrance is 430 ft. For sluicing the entrance channel, a sluicing basin having an area of 250 acres is discharged, and dredging is also practised to obtain a minimum depth of 13 ft. of water below ordinary spring tides in the channel. The harbour entrance has been improved as described in a paper read before the Institution of Mechanical Engineers at their visit to Calais in 1889.

Harbours with Detached Breakwaters. The best protection for vessels (next to an estuary) is that afforded by Nature in the form of a bay, with projecting headlands on each side, which requires shelter only at its entrance, to form a perfect harbour. The construction of a detached breakwater across the entrance provides the necessary additional shelter. A space being left between each extremity of a detached breakwater and the coast (or between each extremity of a detached breakwater and jetties connected with the coast) two entrances are formed. If these entrances are made to face different directions, an advantage is gained, in that one entrance may be used when the other, according to the direction of the wind, may not be convenient. Another important advantage in having a double entrance lies in the fact that a current is generally produced through the harbour, which prevents the tendency towards silting.

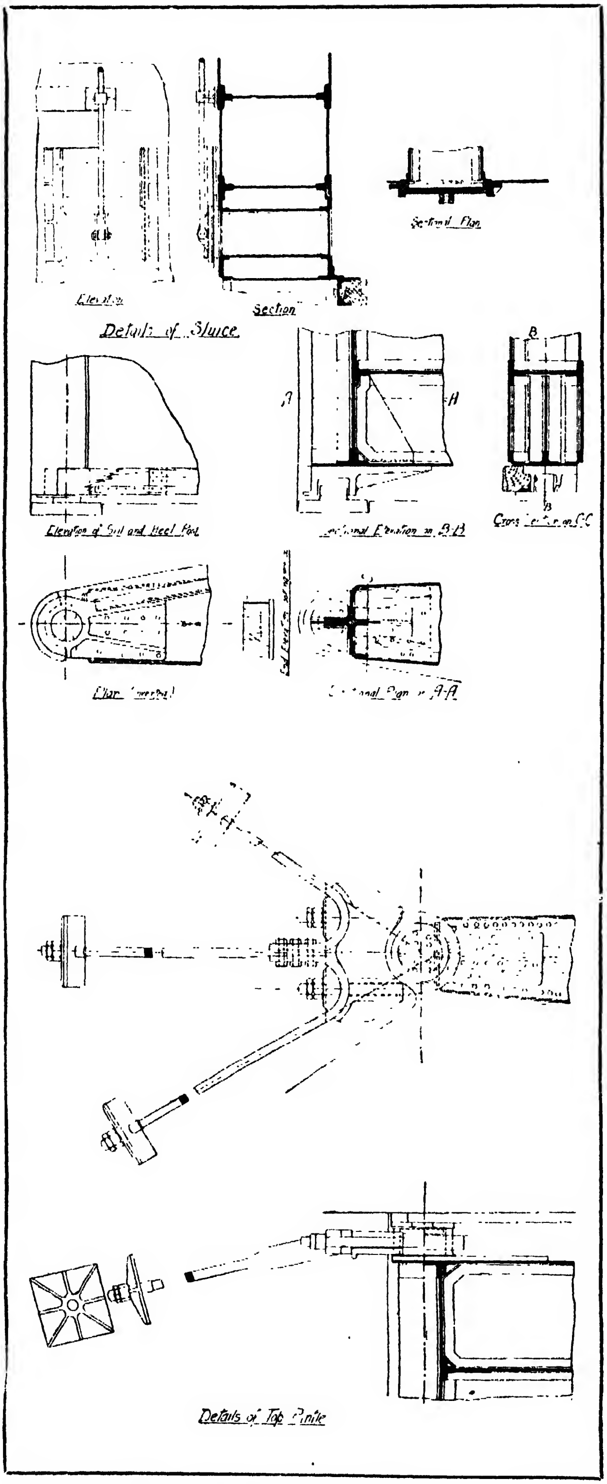
In designing harbours, however, exposed to silting, it is impossible to procure tranquillity without at the same time promoting deposit unless the silt-bearing waters are excluded, in which case the silt accumulates outside instead of inside the harbour.

Dover. The entrance to the inner harbour, 140 ft. between piers, leads to a tidal harbour having an area of about 13½ acres, including the entrance passage. The inside basins form the Granville Dock [1 and 2], which has an area of about 4¾ acres within the gates, its entrance being 65 ft. wide, with 21 ft. clearance over sill at high-water spring tides, and the Wellington Dock, having an area of 8¼ acres within the gates, its entrance being 70 ft. wide, with 15 ft. clearance over sill at high-water spring tides. The Admiralty pier was begun in 1847, and completed to a length of 2,100 ft. in 1871. In 1877 a portion of the parapet on the west side of the pier was carried away during a south-westerly gale for a length of 1,050 ft., and subsequently reconstructed to an increased transverse width. As a whole, the pier has proved to be a stable breakwater, requiring only ordinary maintenance and affording excellent shelter. This pier was constructed to form the western arm of the large harbour then contemplated for the Government Harbour, and has been lengthened to meet present requirements, having been recently extended 2,000 ft., and has a batter of 1 in 12 on the outer face, so that no resistance may be opposed to the upward movement of the water. The inner face has a similar batter, with timber fenders attached to enable vessels to be moored alongside. The average height of the pier from foundation to roadway may be taken at about 78 ft., the base width being nearly 56 ft. The Prince of Wales Pier is 2,910 ft. in length, and was built to give shelter to the east side of the harbour. This pier is 30 ft. wide, but has been widened by means of a landing-stage on the west side to provide for a station. This pier now becomes an inner boundary between the Admiralty Harbour and the commercial harbour.



4. WELLINGTON DOCK GATES, DOVER HARBOUR

Sites for Harbours. Not only is a geological knowledge useful in selecting sites for harbours, but the geographical position must be considered. Bays and indentations of coast-line offer the appropriate sites for harbours, and



5. DETAILS OF WELLINGTON DOCK GATES, DOVER HARBOUR

advantage should be taken of the shelter afforded by natural headlands to enclose the greatest area of deep water within the works. Rivers, while contributing a ready and satisfactory position for trade centres, may have their drawbacks in the shape of swift currents as well as bars and shoals.

Natural harbours form some of the finest harbours in the world, for even when not complete, they in many cases require little alteration to render them safe and commodious.

Breakwaters. The type of breakwater formed of large mounds of rubble, paved on the sea face from low water up with heavy stones so as to present a smooth slope to the waves, has frequently been much damaged by storms tearing away the paved slope and eating into the heart of the work. The type of breakwater formed of rubble mounds reaching from the bottom of the sea to a little over low-water level, along which mound a vertical wall or backbone of masonry is built, having its foundations laid at low-water level, may fail by the sea washing away the foreshore of the rubble and undermining the masonry wall, which is then readily reached by the waves. The type of breakwater formed of rectangular blocks of stone or concrete of comparatively small size, built into a vertical wall from the bottom of the sea upwards, is very costly when the blocks used are small. The type of breakwater formed of rubble mound reaching from the bottom of the sea upwards, along which is built a vertical wall formed of comparatively small blocks—the foundations of this wall being laid not at low-water level, but several feet below low water—is liable to damage from settlements in the mound and from the size and bond of the individual blocks proving insufficient. Large blocks have been used at recent harbour works, the largest, weighing 360 tons, being those used at Dublin by Mr. B. Bindon Stoney.

Except in rock foundations, more or less settlement can seldom be avoided, and the greatest occurs in rubble mounds. Breakwaters built with sloping courses readily accommodate themselves to settlement by an exceedingly small opening of the joints.

A general settlement is of comparatively little importance. A settlement of about 3 ft. 6 in.—approximately one-fifteenth the height of the mound—occurred in the Holyhead breakwater after the superstructure had been built, but the movement was so gradual and regular that the work was not affected by it. In the Colombo breakwater, which is composed of sloping blocks, the settlement amounted to about one-tenth the height of the mound, measured from sea bed to the base of the superstructure. The superstructure followed it down without any appreciable disturbance of the work.

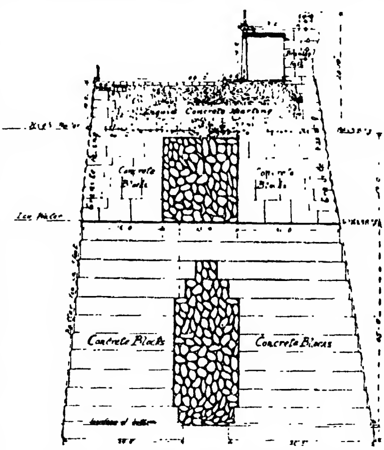
Breakwaters with side walls of concrete blocks and hearting of dry rubble is a form of construction which has many disadvantages, and is suitable only when the amount of exposure is small. The hearting of dry rubble is the chief cause of weakness. There is nothing that commends itself more to the mind of the engineer where a foundation is established upon an unyielding strata obtained at a workable depth below low-water level than continuity of a pier foundation.

Concrete Breakwaters. Breakwaters are also formed of concrete blocks throughout, laid in horizontal courses. The foundation must be carefully levelled to receive the first course of blocks, which necessarily must be laid by divers, the remaining courses of blocks being laid by a "titan," or setting machine. The blocks below low water having to be bedded without any cement mortar, are open to the defect of uneven bearing and possibility of breakage and settlement. All blocks are preferably laid as headers; loose beach stones dropped into recesses left in the sides in a similar manner to holes for dowels serve admirably below low-water level to prevent one block sliding in front of another. Divers do not care to work at a greater pressure than 45 lb. per square inch or in a depth of, say, a little over 100 ft. of water. The foundation sometimes is formed with mass concrete, or with concrete in bags, deposited by means of iron skips of from 5 tons to 20 tons capacity, having their bottoms formed of lids or flaps opening outwards, or with boxes with similar arrangements. Precaution must be taken for concrete bag work to be deposited as soon as possible after mixing. Bag work can be roughly levelled by divers pressing it directly after deposit, and before setting. The bags may be made of jute.

For concrete used in bag work, the most suitable proportions are 1 of Portland cement to 4 or 5 of sand and shingle or broken stone, and quick-setting cement is usually employed. Any voids or spaces between the bags after being deposited can be filled up with small bags or mass concrete. More rapid progress can be made with the type of breakwater composed of concrete blocks laid in sloping courses, as compared with the horizontal block type, and less overhanging is required in the "titan." The scar or free end of the breakwater is more easily protected from heavy seas during construction. The inclination of the blocks is generally about 70° to 76°, and the blocks, besides breaking joint with each other, are bound together by joggles, formed of grooves filled with concrete in bags. Sometimes the blocks have grooves to receive the tongues or projections of the other blocks. In any tendency of the toe of the work to get out of alignment with the angle or slope, compensating courses are introduced.

Rubble Stone Breakwaters. Mound breakwaters of rubble stone are suitable only when an abundant and easily accessible supply of durable stone is available. A mound of rubble deposited in the sea will, by the action of the waves, assume a profile which will be subject to variation for possibly many years without any superstructure built upon them. Plymouth, Kingstown, and Portland are examples of this type of breakwater. In some cases the slopes are faced with heavy stone pitching down to low water; but while it obviates the disturbance of rubble, it increases the scour at the toe of the pitching. Placing a vertical structure upon a rubble mound alters the pre-existing conditions, and an excavating action comes into play owing to the action of the waves against the face of the wall.

The surface of the rubble mound should be carried up well above high water, as at Holyhead; or it should be kept at a sufficient depth at low water so as not seriously to affect the character of the waves, or be exposed to their disturbing action. In the construction of such breakwaters the material is generally conveyed and discharged by means of barges, cranes, etc. The circumstances must admit of an ample width of base. This type of breakwater is sometimes constructed of concrete blocks thrown together upon a rubble bed or base. The voids in mound breakwaters materially assist in breaking up waves and checking their progress. Where a reliable base can be reached at a workable depth the pier can be built up in regular horizontal courses, and a side batter provided suitable for the requirements of the section. In laying blocks in a built-up pier as headers, and making alternate face blocks shorter than the others, the benefit of a transverse bond must be considered. If face blocks in a pier exposed to the action of rough seas are not joggled as soon as the joints become displaced air settles in the apertures, and the effect of rising water is to compress the air, causing the compressed air to force out the block. Dowelling or joggling is adopted in order to prevent the withdrawal of individual blocks, usually made of rich, fine Portland cement concrete, and well grouted into the blocks. Iron cramps and bolts are frequently used.



6. SECTION OF ADMIRALTY PIER, DOVER

Timber Pile Breakwaters. Breakwaters are also constructed of timber framing filled with stones. Where suitable materials can be obtained close at hand and cheaply, this type of breakwater can be constructed quickly, and at a much lower cost than if built of solid masonry or concrete.

When the ground permits, the timber piles can be driven from a travelling stage, and the ties and braces fixed as soon as possible after they are driven. The largest stones being selected for the faces of the breakwater being in their rough state, and no dressing being necessary, they need to be packed together so as to form as close a work as possible. Smaller stones are then used for the interior filling. The filling in with stone should closely follow the completion of the timber work.

Continued

Continued from page 6193

PHRASING AND ARTICULATION

Nuances. Expression and Tone Colour. The Art of Correct Phrasing. Elocution and Declamation. How to Study a Song

By MARY WILSON

"MESSA di voce" has been defined as "the swelling and diminishing of the sound of the voice upon a holding note." To obtain this a note must be attacked *very* quietly, gradually increasing in force until the lou est tone is obtained, then must be diminished carefully and gradually until the original power of tone is reached.

These swelled sounds are shown thus <, >, and this sign usually applies to *one* note only, although it may happen that a whole phrase is to be included. But in either case it must be executed in *one* breath. At first the student must practise half the exercise—that is, begin very softly, making a gradual crescendo from the softest to the loudest tone. This should be practised twenty times, then the process should be reversed, begun very loudly, gradually diminished to a *pp.* This, too, should be practised many times. Finally the whole exercise should be practised.

Rules for Singing "Messa di Voce." The following rules must be observed:

(1) Breath must be inhaled slowly, calmly, quietly, and deeply before each exercise.

(2) The vowel sound must not alter as the note becomes louder or softer.

(3) Once the note is attacked the mouth must remain unaltered.

(4) The quality of the note must be unchanged throughout.

(5) The note must *not* be held until the last particle of breath has been exhaled: a little must remain in the lungs after the completion of the note or phrase.

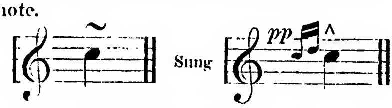
The "messa di voce" may be practised on all the notes suitable for the respective voices, given in Ex. 1 [pages 6183–4], the vowels A (ah) and E (ee) being used.

The object of "messa di voce" is to give colour to the singing. It must not be attempted until the student has acquired a correct management of the breath.

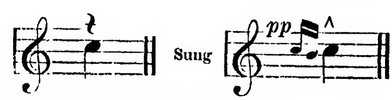
The principal ornaments used in singing are the appoggiatura, acciaccatura, mordente, grupetto or turn, shake or trillo, portamento, legato, staccato, and picchettato.

[For appoggiatura, acciaccatura, grupetto or turn, shake or trillo, see page 271.]

The mordente consists of the written note, the note above—either tone or semitone—and the written note.

Written Sung

There is also the *inverted mordente.* This consists of the written note, the note below and the written note.

Written Sung



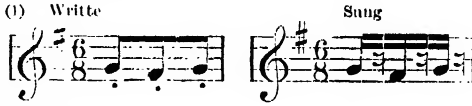
By portamento is meant the "sliding" of the voice from one note to another of different pitch. When used with discretion it is very effective, but a common mistake made by many singers is that they use it continually without discretion. As to how it must be sung—slowly, or quickly, loudly or softly—the student must be guided entirely by the context. The following sign ⌒ or ⌒ is used.

A note must never be "slurred" to and then from consecutively.

The sign called a slur, used for the legato, is written ⌒. The notes over which the slur is placed must be sung very smoothly, but there must be no "sliding" of the voice from one note to the next, and the notes intervening between the written notes must *not* be heard as in portamento.

Great care and perseverance must be exercised before the legato can be acquired; but once the student has mastered its difficulties, he is amply repaid, for, as Signor Randegger says, "Efficiency in *legato singing* is the most prominent and valuable attribute of a good singer."

Speaking generally, it may be said there are three kinds of staccato.

(1) Write Sung

(2) Written Sung

(3) Written Sung

No. 1 is usually called staccato, and No. 2 picchettato. The notes marked picchettato are half as short again as those marked staccato.

The strictest attention must be given to the rests between the notes; neither the voice nor the breath must be heard.

Breath must not be inhaled between the notes, but that which was inhaled at the beginning must be regulated so that it is sufficient for the whole phrase. Each note must be firmly and sharply attacked.

In singing No. 3 the notes should be firmly attacked, but not so marked or detached as in Nos. 1 and 2. The student is advised to write exercises for himself on the different ornaments and embellishments, and then practise them carefully and diligently in the keys best suited to his voice.

Word Picturing. Upon "word picturing," facial expression, tone colour, emphasis, expression, and phrasing, all to a large extent depend. Each of the above will be treated separately; but it is essential that the student should first really understand what is meant by "word picturing."

Before a student can do justice to a song he wants to sing he must take the words apart from

the music, read them through carefully and thoughtfully, then re-read them. They may be merely descriptive, or they may be of an emotional nature combined with description. No matter of what nature they may be, the student must draw upon his imagination and make *mental pictures* of the scenes and emotions to be portrayed, as an artist has to do before he can place on canvas illustrations of a poem.

To a painter this word picturing is, perhaps, more natural than to a singer; the former is trained from the first to make a mental picture of all he reads. Here is this difference between the painter and the singer: as the latter will probably have to describe the whole of the poem, he must, perforce, *mentally see* the *whole* of it, whereas the painter is limited to a few lines, for he cannot paint a picture illustrating the whole of the poem.

The student will find it very helpful—until he is able to draw upon his imagination more, and mentally make pictures for himself—to recall past experiences in his life, and work on them. For example, if he is singing of a lovely garden, or a quiet graveyard, he must think of some garden he knows that once appealed to him, or a quiet, peaceful graveyard he has seen and noticed; if he is singing of a person, he may think of someone he knows who seems to fit the situation; if his song refers to the passions or emotions, he must think of the time when he hated, was afraid of, loved, or was angry with some person, and he must try and recall some of the feelings he may then have experienced, and work them into the song. The whole of what is represented in the song must be *mentally seen* if he wishes to make the rendering of it clear to his audience.

Facial Expression. For examples of real facial expression one should look at the face of a child. How quickly its little face brightens, and with what smiling eyes it looks at one when anything pleases it! On the other hand, how suddenly its wee face clouds if it is disappointed, and how it pouts when it is cross!

As the child grows up it gradually loses this natural unconsciousness of self, and perhaps unconsciously strives to hide these varying expressions which are the outcome of the thoughts and emotions. English people are much too reserved: they will not speak with their eyes and the expression of their faces—they rely entirely upon the mere words.

For those whose calling does not bring them before the public, this may be passable; but to anyone who wishes to be a singer, reciter, or public speaker, facial expression is as essential as a properly produced voice. The expression of the face must change with the mood.

No hard and fast rule can be laid down for facial expression, as all the expressions natural to one's face are the outcome of one's inmost thoughts.

The student must make a list of the different emotions—love, hatred, rage, and so on, and, standing before a mirror, practise the different facial expressions which represent each. He will see for himself how necessary it is to get a thorough reading of his song, and practise his "word picturing." When these have been mastered, facial expression will come quite naturally to him.

Tone Colour. When the student has thoroughly grasped the meaning of the words of his song, and made himself quite familiar with all the moods contained therein, he will unconsciously have acquired the correct "tone colour" for each musical sentence. He would not use the same "tone colour" for "O rest in the Lord: wait patiently for Him," that he would for "Awake, Saturnia, from thy lethargy!" For the former he would use a warm, comforting, persuasive tone, whilst for the latter he would use a sharp, commanding, peremptory one. Ere the student can hope to attain proper tone colour, he must thoroughly understand the words he is about to sing.

Emphasis. Some singers may argue that "emphasis" does not apply to singing; that it chiefly concerns readers, reciters, and speakers. This is not so; it is as necessary to the singer as to the speaker. Every word in a phrase must be given its due importance, but one of them must be more strongly emphasised than the others, to point to the real meaning of the sentence.

The whole sense of a passage may be altered if emphasis is not put on the right word. The following examples show the correct and incorrect emphasis: "Greater love hath *no* man than THIS, that a man lay down his *life* for his friends." Properly emphasised, the word "*this*" takes the especial prominence, whilst the words "no" and "life" are the next in importance.

Wrongly emphasised, it would read as follows: "Greater love hath no *man* [as opposed to "woman"] than this, that a man *lay down* [not "take up"] his life for his friends."

The student will see for himself how this sentence can be turned about, and wrongly emphasised and made absolute nonsense of: further, he will see how essential it is that singers, as well as speakers, should emphasise correctly.

Expression. Rosseau says: "Expression is the power whereby the musician conveys to his audience all the ideas and sentiments of the music which he interprets, at the same time making it evident that he feels them himself."

Some natures are less responsive than others, but with patience, perseverance, and a tactful handling, feeling can be brought out of the coldest natures. The terms expression and feeling, as applied to singing, are synonymous, therefore every person is capable of singing with "expression."

Expression cannot actually be taught, but it can be cultivated, and to such an extent that the performer really feels what he is singing; and, what is still more important, makes his audience feel it, too. There are, of course, some people whose singing is naturally sympathetic and full of feeling, but this need not discourage the less fortunate ones, for everybody who wishes can sing with expression. The easiest and quickest way to cultivate this great gift is to read good literature, especially poetry, thoughtfully and with understanding.

Phrasing. Phrasing may mean merely a correct punctuation of a musical phrase, as: "Woe! Woe unto them who forsake Him!" (Elijah); but when one speaks of a song and piece being correctly "phrased" one generally understands that the best possible effect has been given to each of the musical sentences contained therein. This can only be accomplished after the performer has thoroughly grasped the *meaning* intended by the composer, and fully realised his ideas; he will then portray them in such a way that the audience cannot fail to grasp them too.

Besides this, he must have mastered the art of breathing, have had his voice properly produced, have studied articulation and pronunciation, be able to keep time and sing "in tune," know where to take breath, be able to use the correct "tone colour," be able to sing legato and staccato, and be thoroughly proficient in the singing of all the different ornaments and embellishments.

Lamperti, in his famous "Art of Singing," says that "the whole beauty of the art of singing lies in phrasing."

We give on the next page "O rest in the Lord" fully marked, and the student is advised to study it well. For his guidance we also give a list of the signs used:

√ Where breath is to be inhaled.
| Voice to cease, but no re-inhalation.
/ Inflection of the voice to rise.
\ Inflection of the voice to fall.
∧ Strong accent.
– Medium accent.

Articulation. The great mistake so many singers make is that they give their undivided attention to the fulness and beauty of their voices, paying no heed to the diction; the words count for nothing, and are never thought of at all. It is as essential in singing as it is in speaking that the words should be clearly heard and the correct accent used—in other words, that the articulation and pronunciation should be irreproachable.

Articulation must not be confused with pronunciation, for there is a great difference between them. Words are made up of syllables. Each syllable contains one vowel and one or more consonants. When each vowel and consonant is clearly and correctly uttered, the *articulation* is perfect. The reason why English people articulate so indistinctly is that they hurry over their words. More *deliberate* articulation is needed. The famous Mrs. Siddons used to say to her pupils, "Take time!"

It will be found that the consonants offer greater difficulties than the vowels, so the first exercises will be on the consonantal powers.

It must be borne in mind that the consonants are not all formed alike. Roughly speaking, they are divisible into five groups:

1. LABIAL, formed by the approximation, or the complete contact, of the lower and upper lips—pen, bat, man, wench.

2. LABIO-DENTAL, formed by the contact of the lower lip with the upper teeth—fine, verse.

3. LINGUA-PALATAL, formed by the tip of the tongue coming into contact with the hard palate immediately behind the two upper front teeth—ten, did, line, night, sell.

4. LINGUA-GUTTURAL, formed by the back of the tongue coming in contact with the hard palate—kind, gag.

5. ORAL, formed by a full flow of breath through the mouth—hall, yolk.

The student must first persevere with the actual powers themselves, and not add the vowels until the consonants have been *thoroughly* mastered, thus:

B as in bad	N as in name
C „ cakes	P „ pill
D „ dane	Q „ quilt
F „ fight	R (trilled) as in rat
G „ gauge	R (smooth) as in war
H „ hat	S as in sill
J „ jet	T „ tone
K „ kick	V „ vain
L „ lark	W „ well
M „ mart	X = KS as in mix

Wh as in white

Each of the powers given in the above list, beginning with B, must be practised at first *very slowly*, thus: B'B'B'B, breathing after each B. Then in four groups of two, breathing after each group; four groups of four, breathing after each group; four groups of eight, breathing after each group; then in groups of twelve, sixteen, twenty, and so on. The greater the speed, the lighter and crisper must be the articulation. The sound actually uttered is not Bee, but B as heard in the word "bad" minus the "ad" sound.

After having practised the above exercise the student should make out lists of words for each consonant, thus: Ball, bat, bell, bed, bile, bid, boy, boil, book, booth, etc. Then sentences something like these: "Black Benny Bumpkins bought beautiful blackberries, but Bertha Brown bartered Benny's best boat for bananas."

This must be practised carefully in two breaths—that is, breathing after blackberries; then the whole exercise in one breath; afterwards tried twice, three times, and four times, if possible, in one breath, throughout paying the greatest attention to the "B" power.

Having learnt something of the consonantal powers, the student must turn his attention to the vowel sounds. Whilst only five signs are used—A, E, I, O, U—they represent a great many more vowel sounds.

Five sounds for A, as in ape, ah, all, at, air.
Three sounds for E „ eel, ell, earth.
Two sounds for I „ ice, ill.
Two sounds for O „ old, odd.
Three sounds for U .. up, (n)ude, (f)ull.

O is also represented in the diphthongs, as in boy and owl.

Although the vowel sound emanates from the larynx, the real formation is decided by the different shapes assumed by the inside of the mouth and the pharynx.

The student must make for himself lists of words on each of the vowel sounds given above, thus: A as heard in ape, ale, fate, pate, grate, and practise them many times, listening carefully to each sound produced, and continue until he has thoroughly mastered them.

When he has overcome the difficulties in the preceding exercises, he should take sentences such as this from Ruskin:

"Blue, baseless and beautiful
Did the boundless mountains bear
Their folded shadows into the golden air."

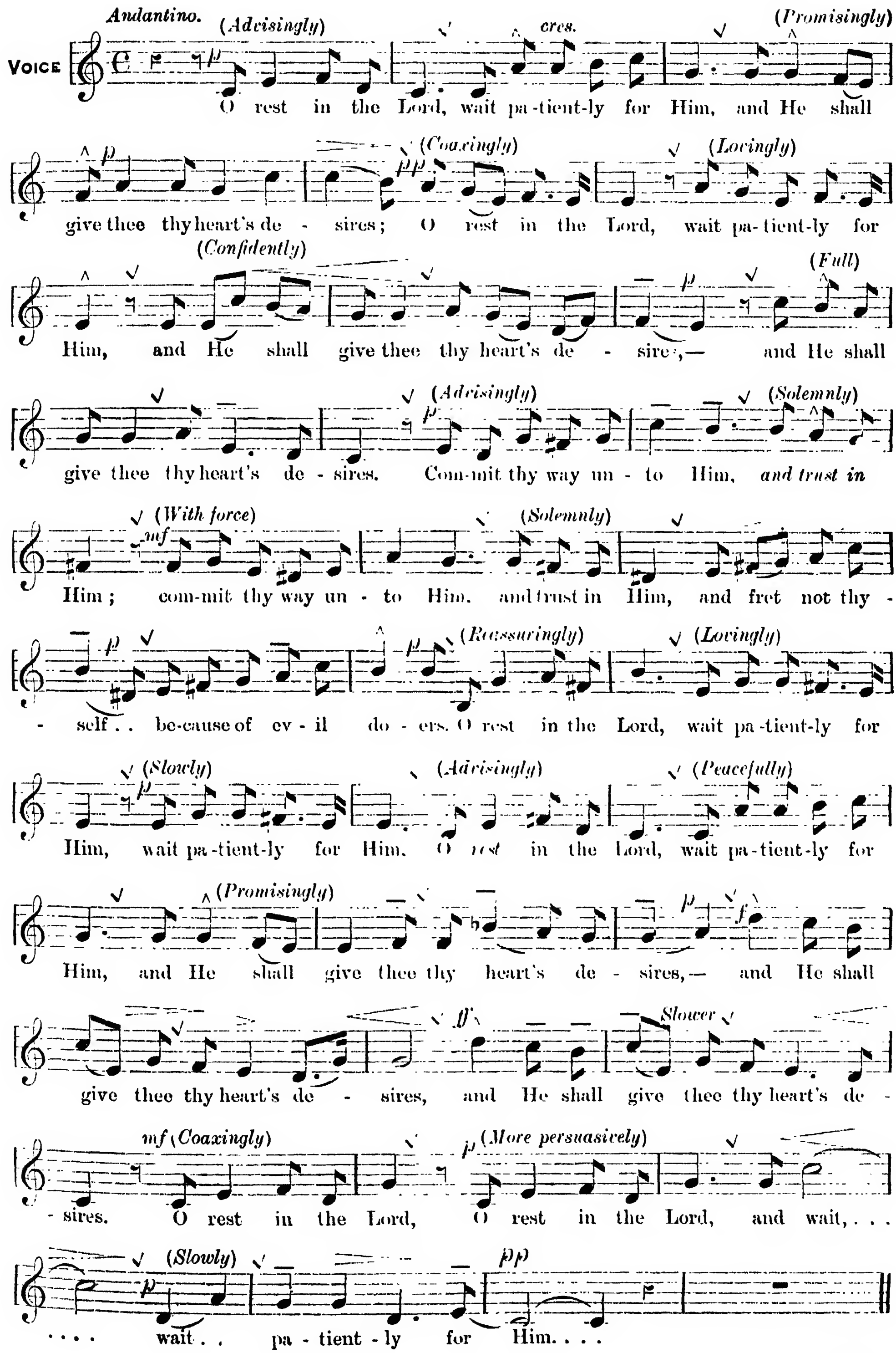
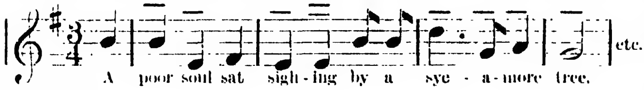
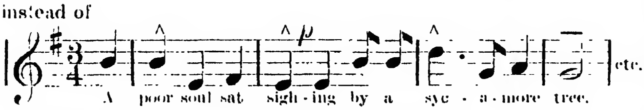
Recite them very slowly, and pronounce every vowel sound fully, correctly, and distinctly.

Pronunciation. Good pronunciation is really "propriety of delivery." It is not so easily taught as is articulation; so much depends upon the student's own intelligence and his capabilities for hearing and discriminating between words correctly and incorrectly pronounced.

To a very large extent, correct pronunciation depends upon their proper use; but besides practising the vowel sounds, it is necessary to hear, listen to, and copy the best orators and actors of the day if good pronunciation is to be obtained.

Apart from the different brogues of Scotland, Ireland, and Wales, the English counties have peculiarities of pronunciation that ought to be eradicated, such as: "t' cat" for "the cat" (North Lancashire); "th' cat" for "the cat" (South Lancashire); "Charing-Crawss" for "Charing Cross" (Cockney); "Eow" for "Oh" (Cockney); and many more that can only be corrected by listening to a cultured speaker. It is not intended that the student should regard pure dialects as vulgarisms; it is the mixture of "polite speech" and dialect that is so ugly. In a number of real dialect words many of the roots of the English language are traceable, for they are chiefly of Celtic, Teutonic, Scandinavian, and Anglo-Saxon origin.

It is generally imagined that the English language is bad for singing. The sooner this absurd idea

Aria—"O REST IN THE LORD."

is abolished the better. The real reason why a voice does not sound so full and resonant when singing English words as it does when singing Italian is that the singer neglects to give the full value to the vowel sounds, and does not articulate his consonants sufficiently, besides invariably "clipping" them. Another common mistake made by singers is that they are not careful to give each syllable its proper accent, for example:

instead of

As first marked, the words would read as follows, and make no sense:

"A *poor soul* sat *sighing* by a *syc-a-more tree*." We do not pronounce the letters s y c a m o r e as *syc-a-more*, but syc-amore, so why sing the word with three accents?

The consonants must be more marked in singing than in speaking, because the vowels are more prolonged and have often to be made broader.

Great care must be taken that the end of a word is not carried on to the beginning of the next—that is to say, it must be finished on the note intended by the composer: the consonants must be articulated distinctly, especially the d's and t's; and the r's trilled where necessary, but under no consideration must false accents be introduced in the endeavour to begin or finish the words.

Elocution and Declamation. It is essential that the student of singing should study elocution and declamation. Unless he does so he will find it almost impossible to deliver his song to its greatest advantage—to give it the poetical sense and the true expression intended by the composer. Many teachers of singing are quite opposed to their pupils' studying elocution and declamation. They imagine it injures the singing voice; but this is an absurd idea. If the student uses his speaking voice properly and in moderation, no possible harm will result. Cavaliere Alberto Randegger, one of the most famous professors of singing, writes: "Elocution and declamation should form an integrant part of the singer's education." [See ELOCUTION.]

A dictionary would probably describe a song as a short poem, a ballad, a lay or a strain, but none of these synonyms fully define the word. A song is the combination of words with the singing voice. One is indispensable to the other, and they are equally important. When it is remembered that words set to music make the conception absolute, it will be seen how important a part they play.

The First Song. The first song chosen should be very simple, slow, sustained, well within the compass of the voice, the intervals not too difficult, and the accompaniment quite easy, so that if the student is obliged to play his own accompaniment he can do so without paying much attention to it, and so give all his thoughts to his voice and the words. A short song such as "The Sweetest Flower that Blows," by Hawley, or "The Night has a Thousand Eyes," by Frank Lambert, is recommended.

The student must read through the words carefully, and when he has grasped their meaning read them aloud as though they were the outcome of his own thoughts, breathing where the sense dictates.

Before beginning to sing them he is advised to learn them by heart. He should then give his attention to the song, first noticing the key, time, and marks of expression before uttering a sound. Next he should slowly sing through the melody to "La," keeping perfect time; and finally he should take the words and music together.

Recitative may be defined as a musical declamation or a speaking in music. There are two kinds—accompanied and unaccompanied. In singing the former the student must keep strict time. Example: "Awake, Saturnia" (No. 28, Handel's "Semele").

When a recitative is unaccompanied the singer makes the time according to the words of the story and his own reading of the piece. Example: "O, worse than death" (No. 17, Handel's "Theodora").

For both accompanied and unaccompanied recitative singing the meaning of the words must be very carefully studied, so that the sentences may be correctly phrased and the proper emphasis given. At all times must the words be clearly pronounced.

When studying the unaccompanied style, the student is advised to select several recitatives, and take the words quite apart from the music and read them aloud as he would a verse of poetry or a piece of prose. Having satisfied himself that he has obtained the correct meaning and effect, he may then sing them, but the phrases must be the same as when declaimed.

Three Styles of Singing. Generally speaking, there are three styles of singing—plain, florid, and declamatory. For the first the essential and distinct attributes are perfect intonation, correct breath management, and faultless diction. This is the noblest of all styles, and to it belong church music and oratorios. Example: "If with all your hearts" (Mendelssohn's "Elijah").

The florid style is not so frequently heard nowadays as it was some years ago. It is full of ornaments—grace-notes, shakes, turns, arpeggios, scale passages, etc., and the "tempo" is usually quick. For the singing of this the voice must be light and full, and the breath well under control. Example: Bishop's "Lo! here the Gentle Lark."

It is to the delivery of the words that the attention is chiefly given in the singing of the declamatory style; vocalisation is practically unnecessary. Example: Schubert's "Aufenthalt."

The Young Singer's Début. It is quite possible that the average student will feel very nervous and awkward when he makes his début as either a professional or amateur singer. This is natural enough, and only time and experience will enable him to obtain perfect self-possession; but he should bear in mind that however nervous or anxious he may feel he must do his utmost to hide it, for nothing is more trying to an audience than a nervous performer. He should come well forward on to the stage, and his face should assume a pleasing expression. The student may at all times be *anxious* when he sings publicly, but it is certain he will not be nervous if he understands and has thoroughly mastered the piece he is about to sing.

SINGING *concluded; followed by* PIANO TUNING

IN BUSINESS AS A BUILDER

Continued from page 6214

Training. Office Work. Estimating from Bills and Drawings. Measuring-up. Extras. Day Work. Building Abroad. Books for Builders

By Professor R. ELSEY SMITH and R. L. ROBERTS, M.A.

At the time of writing the building trade throughout the country is passing through a period of almost unexampled depression, and cannot be said to be a very attractive or lucrative business for a young man to enter. This is not the place to discuss the more immediate causes of this depression, but it will be as well before the subject proper is dealt with to call the reader's attention to the great changes which have taken place within the last twenty years in the trade, and have most vitally affected it.

Changes in the Building Trade. There is no doubt that for the moment, though it is to be hoped not permanently, the old-fashioned type of builder is on the decrease; the builder who had first-hand practical knowledge of some or all of the trades employed in the erection of buildings, who had gone through a most practical training in the workshops, and who, in proportion to the thoroughness of his training, took pride and interest in his business—this type of builder is being pushed to the wall in the stress of modern competition. His success depended not merely on his ability to undercut his competitors in a tender list of twenty but on a reputation gained for sound, though not always, it must be confessed, cheap building; and it is open to grave doubt whether the building public in the end stands to gain by the gradual disappearance of this type. Into his place is stepping the mere financier, who chooses the building trade as the field of his operations, and whose training has made him a master of office detail, but has left him without any practical knowledge of the various trades connected with his business. Besides the change in the type of builder, there is another tendency to be noted, which is, perhaps, its necessary concomitant—that is, the tendency on the part of large furnishing and drapery firms to establish an architectural and building branch of their business, and with the help of the large capital they have at their command, to enter into competition with the genuine contractor: for in these days of rush and hurry it is apparently a tempting consideration to be able to choose your house at the same place as you buy your furniture. It should be noted, however, that the competition of these firms has at present more effect on the decorative side of a builder's business than on the actual contracting, though not without its influence here, too.

Signs of the Times. These changes are undoubtedly signs of the times, and must be taken into consideration by any one proposing to enter business as a builder; but, significant as they are, there are reasons for hoping that they indicate a mere temporary phase, and not a permanent alteration of the conditions under which the building trade has been carried on in this country. Architects, too, it is to be hoped, will be found on the builders' side in this struggle; their work is far more likely to be intelligently and efficiently carried out by firms whose interests lie only in the building trade, and whose principals have practical knowledge of building detail, for they will thus secure the great advantage of dealing direct with such builders instead of with the subordinates of great financial houses, as they would have to do if the "trust" methods of business were to prevail in the building trade.

Technical Training. Technical training may be said to be the foundation stone of success for the builder and of most vital importance if he wishes to have a real knowledge of his trade and a living interest in his business, and in these days, such training is open to all. The old order, it is true, has changed. The days of apprenticeship, whether for good or ill, are gone for ever, but the intending builder has no lack of efficient substitutes. Thanks to the various technical institutes in London and throughout the country, practical training in all the various building trades lies within his reach at a very slight cost. Some of these polytechnics have a course of day classes for intending architects and builders, where they can learn both the theory and the practice of their business; and after having been through such a course, the student, though not master of every trade, should be sufficiently acquainted with them to know good construction from bad, and to realise whether the workman in his employ are efficient or the reverse. Perhaps the ideal training for a builder is a course of these technical classes, and at the same time attendance on a building in the course of erection. From the latter he would be able to learn not only how a building is put up from the foundation to the finish, but also to gain some knowledge of the handling of workmen and the general management of a job.

Office Work. With these remarks as to the preliminary training advisable for a builder, our subject naturally falls under two heads—the builder's work in the office and his work outside in supervising and managing his jobs. It is not at all uncommon in building firms where there are two partners for them to divide the duties, one taking entire charge of the estimating work in the office, and the other visiting the contracts in hand, seeing to the ordering of materials as they may be required from day to day, and settling any question that may arise on the work itself. The convenience of this division of labour is quite obvious, but it is not a desirable method to employ. A builder should know all sides of his business, that if need arises—as it is sure to do—he may be capable of dealing with any branch of it. The office work is by far the more important of these two, though the term may be slightly misleading. By it is meant not the mere daily routine of the office, which, with little variation, would be the same in a builder's as in any other, but more specifically preparing estimates and all that has to be done in the attempts to secure contracts. This side of the business presents far greater difficulties to-day than it did twenty years ago. The fight for work and the competition in the building trade becomes fiercer every year; prices are cut to their lowest point, not only by those who may be called the "plungers" of the building trade, and in this severe struggle for work, scientific pricing of estimates is

sometimes thrown to the winds, the writer knowing of more than one case where a builder, after making up his estimate, has taken off a good round sum "for luck," as he says. With this increase of competition there must be a corresponding increase in intelligence on the part of the builder if he is to keep his place in the ranks of the successful.

The modern builder must be prepared to face the new conditions, for though some of the severe competition is due to temporary depression, it is in the main due to causes that will probably prove permanent. The public have demanded the cheapness that unlimited competition gives, and architects have been compelled to bow to the popular demand. The builders, too, have themselves to blame in part for this state of things; when tender lists were more select, the work was often too costly, and the inevitable reaction on the part of the building public was bound to come. Under these conditions, the estimating side of a builder's work has become more than ever important and increasingly difficult, and it is no exaggeration to say that it is only after the most assiduous application that skill and certainty in estimating can be obtained.

Invitations to Tender. There are certain kinds of public work that are advertised, and are open to public tender, and there are some builders that almost confine themselves to this kind of work. Speculative work, also, is, of course, open to all builders with capital, or with the ability to borrow capital. But apart from these two classes of contracts, it is difficult, even in these days of competition, for a builder to obtain the opportunity of submitting a tender. Architects, quite naturally, send their work to the men they know, and of whose skill and trustworthiness they have had experience, and unless specially advised, would not include in their lists of "invited to tender" a builder unknown to them; but if recommended to them, architects are not hostile to the young and untried man, and are quite willing to give him the necessary opportunity. For instance, a London architect, with a job outside the London area, would always ask, in addition to his usual list of builders, the local builder to tender, if satisfied of his capacity, because, if for no other reason, he should be able to carry out the work at less cost than his London competitors. The difficulties of obtaining the entrée into the "invited to tender" lists are great, but not impassable, and should not debar any man of capacity from entering business as a builder.

Estimating. A builder may have to estimate for contracts in one of two ways — either from quantities or from drawings, and in the latter case, he will have to take off his own dimensions. In modern days quantities are almost always supplied, and it is only in the case of small alteration jobs that a builder would have to take out his own—not many of the principal builders would take out their own in competition for a large contract. It is far easier to estimate from quantities than otherwise; but even then one of the most difficult tasks a builder has to do is to prepare a correct and careful estimate. It is a comparatively simple matter, by low pricing, to secure a contract; but it is much harder to prepare an estimate that will not only secure that, but also show a profit at the end of the job. To all who know anything of the building trade it is common knowledge that there is often a variation of from 20 per cent. to 30 per cent. in the prices of different builders tendering for the same job, and all quantity surveyors can testify how greatly the different prices of different builders vary in detail—some pricing their brickwork low and their joinery high, or vice versâ. This variation can be easily understood if the detailed and many-sided knowledge that is required for accurate pricing is taken into consideration. In the ordinary building there are a dozen or so different trades employed, and the estimating builder must know not only the prices of the various materials needed for these trades delivered to a certain site, but must also have some idea of what the labour on these materials will cost; and it is precisely the latter, or the human element, of which it is so difficult to ascertain the cost.

In passing, it may be remarked that the price book is not to be relied on as a certain guide, although it is very useful for occasional reference. A builder should be able to price the bills of quantities that come to his office from his own first-hand experience; this is not to say that he is never to employ an estimating clerk—most builders do—but it is unwise to depend on him entirely.

Estimating from Quantities. Before beginning to price his bill of quantities, the builder must satisfy himself as to one or two points which might seriously affect the estimate he will be giving. Common-sense will, of course, tell him that building is more expensive in some parts than others—for instance, that in a hilly suburb of London, like Hampstead, it is more costly for him to do work than in the centre of London; all materials would cost more, owing to the heavy cartage, but such knowledge as this he will have from his own general experience. His first business should be to visit the site of the proposed building; he should discover what facilities there will be for the storing of materials—limited space for this purpose will mean increased cost—whether the site is easy of access for carts to draw into, and whether there are any special difficulties connected with it. He should satisfy himself as to the nature of the soil—whether, for instance, it is easy to work or not, and whether sand or ballast can be had from it. Another important point to see to is whether there is likely to be much water met with during the excavations. There is in most bills of quantities a clause to pump or bale out all water met with in the course of the work, and this, in some cases, would amount to a serious item. The estimator having ascertained such points as these on the spot, can return to his estimating with the knowledge that will materially affect him in his pricing, and before settling down to his work he should call and inspect the drawings, that he may know whether the proposed building is a simple one, or likely to be expensive, because of minute and elaborate detail, the designs of different architects varying considerably in this respect, and appreciably affecting the cost of their work. When beginning the actual pricing of the bills, the builder should have before him the cost of various materials, such as bricks, cement, etc., delivered to the site, and the cost of carting soil and rubbish from the works, this last item varying from 10 per cent. to 15 per cent. in different parts of London. He can sometimes deduct something from the prices thus obtained before tendering, as the merchants are likely to quote him lower prices if he succeeds in obtaining the work.

Fluctuation in Prices. It is the more necessary to obtain such prices, because the cost of some materials varies appreciably—sometimes from month to month. Metals such as lead and iron are very liable to be affected in this way, and if there is a considerable amount of such material in a bill of quantities it is advisable to obtain from the

merchant a price that will be guaranteed for a time sufficient to allow of ordering at that price if the tender should be accepted; otherwise the builder may find himself in serious difficulties. A concrete instance will at once illustrate this. A builder gives in an estimate for a contract in which there are many hundredweights of lead; he comes out lowest in the list of tenders, is accepted for the work, and begins operations about a month after the sending in of his estimate: he will not require his lead either for external or internal work for many months. He has priced this in his estimate at £15 per ton; between the time of sending in his tender and his wanting the lead it has gone up £3 or £4 per ton, and if he has made no contract with his lead merchant at the time of starting his work for lead to be delivered to his works as and when required within twelve months, he stands to lose very heavily in this part of his work. The same would, of course, be true of any other materials, but metals are particularly liable to fluctuation, and the market in them should be very carefully watched by the builder. It should not be forgotten, too, that in the case of lead, the merchants have formed a ring, and that there is not the free and open market in this material that there is, say, in bricks or cement.

Preliminary and Other Items. The preliminary items should be given careful attention in pricing, especially the time given for completing the contract—almost always inserted by surveyors in the bill of quantities—and the time required for maintenance after the building is completed; this varies from three months and upwards and is sometimes as long as twelve months, and can be a very serious item. A case came within the writer's own knowledge where the time for maintenance was eighteen months; the contract was for redraining a large estate, the drains of which had settled owing to the shifting of the ground. The builder was made liable in the contract for damage to the houses on the estate during the time his work was going on, and for eighteen months afterwards for any damage due to the work being carried out; it is obvious that with a treacherous soil this might be a very serious matter for the contractor. Two other items that should be carefully noted are the fees for the district surveyor and local authorities, and for the water required for the works. In the case of alteration to large buildings, should the quantity surveyor not have included a sum for the fees as a provisional amount, the builder would be well advised to write to the district surveyor and ask him what his fees would be. As to the water, the charges of the different water companies vary, but their fees can be obtained from any textbook, such as Laxton's. The weight of the pipe required by the companies for services is the same throughout the London area, but in some cases outside that area the service pipe is required to be heavier even than the London Board's Regulations, and the unwary builder may get caught in this way. In such a case the builder should write for the water company's regulations and requirements.

Specialities and Provisional Amounts. Where bills of quantities contain specialities such as a large amount of granite work or terra-cotta, the estimator should always obtain prices, however experienced he may be; they are quite outside the run of his ordinary knowledge, and it is imprudent to risk making any mistakes—mistakes in estimating are expensive luxuries. Provisional sums play a very large part in modern building contracts and sometimes form a considerable portion of the whole, and such specialities as those mentioned above are very often included under the heading. The continued increase in such amounts has been brought about by the great changes in modern building construction and the consequent elaboration in such matters as steel construction, sanitation, and the heating of buildings. The gradual elimination of timber and the substitution of fireproof construction in both floors and roofs has deprived the builder of much of his work, and in some cases reduced him merely to the position of general banker for the contract without any of the usual advantages of that position. For though in the bills of quantities the estimator is always instructed that he must add his profit to such provisional amounts, if he really wants the work he never puts anything on, and all he can be certain of getting out of them is a small cash discount such as 2½ per cent., and this even is not always allowed by the special firms employed on a building.

Closing Remarks on Quantities. The estimator should always carefully read through the headings that precede the bill of every trade: they usually consist of the description and quality of the materials to be used, but there are sometimes items that require pricing and others that call for special attention. There was a bill of quantities within the writer's experience where, included in the headings of the joiner's bill, was a clause that the first instalment on the contract would not be paid until all the doors had been got out and framed together, an item that quite escaped the estimator's notice. If there is any pulling down or any other spot work to be priced this should be done on the site itself; it cannot be properly done in the office. If it is stated that the builder will be allowed to use such of the old materials as are sound and suitable, only a visit to the site and inspection of the existing building and fittings will enable him to tell what credit he should allow under this head. Before finally making up his tender the builder should see the specification and contract. It is true that usually all the items that require pricing are inserted by the surveyor in the bill of quantities, but it is best to make sure. Nowadays, in estimating it is usual to add the profit on each separate item. A better though little used method is to price each item at the prime cost and add a percentage at the end for office expenses, use of machinery, the general superintendence of the job, and for profit. This way is old-fashioned and the modern surveyor is not used to it, but it is to be preferred, for two reasons—it makes pricing more scientific and accurate, and in the case of additions and alterations it certainly tells in the builder's favour to have a definite percentage added on to the whole, especially where there are items for which there is no price in the schedule.

Estimating from Drawings. If estimating where quantities are supplied is difficult, the task is doubly so where there are no quantities and the builder has merely the drawings and the specification to rely on, or in some cases where no drawings are needed, the specification only. Such cases are almost unknown with buildings of any size, and only in contracts not exceeding £1,500.

There are two kinds of work for which it is very usual for a builder to have to estimate without quantities—small alterations and additions to existing buildings, and repairs and decorations. In the case of the first, drawings would be supplied, and from these the builder can get a surveyor to

take off the quantities for him if time should be allowed, though often he has the loan of the drawings only for a day or two; but, in any case, builders of experience would prefer to take off their own quantities, and this is not a difficult matter if the builder has an ordinary working knowledge of drawings and dimensions. He will not do it, of course, with the accuracy and fulness of a surveyor, and his method will be rather rough, but, backed by experience, it will suffice. Without experience, however, the builder had far better go to the small expense of employing a surveyor than blunder along as best he can. Or if this is not feasible, owing to want of time, he had better decline to tender. In the case of repairs and decorations—much the most common—the estimator must take the specification with him to the job in question, and do all pricing there, measuring the work in the different rooms, starting at the top and working downwards.

Measuring Up. If estimating preliminary to the obtaining of contracts is the most difficult task a builder has before him, a scarcely less difficult one is the measuring up the extras and omissions on the completion of a contract, and settling up the accounts. That no contract is ever completed without extras and omissions is almost a truism. Building operations do not lend themselves to terminological exactitude, and not the most skilful architect or surveyor can foresee all the contingencies that may arise during the course of the work, much less control the changes of mind to which building clients are so liable. The questions arising from these variations in a contract of necessity lead to much discussion between builder and surveyor, and the builder needs tact, judgment, and good temper if he is to deal successfully with them. In addition, there may be also matters arising out of the bills of quantities. The builder may find them deficient in certain particulars, or may think certain items insufficiently described, or the labour to an item not properly taken. In all such matters there is plenty of room for difference of opinion. The builder is naturally anxious to get all that he considers himself legitimately entitled to, and the surveyor is equally concerned to see that the builder does not get more than his rights, though his position is not one of a partisan, but of an umpire—a position from which builders can rely on most quantity surveyors not deviating. Now, in measuring up as in estimating there are two courses open to the builder. He can himself meet the surveyor and go into all the various questions with him, or he can employ another surveyor to act on his behalf. In the case of large contracts there is much to be said for the latter course, or in cases where the builder foresees that acute disputes are inevitable, and that, in consequence, first-class expert advice will be of the utmost help to him; for it may well be that in such circumstances the builder will have neither the time nor the ability adequately to present his own case, and the extra expense of employing a surveyor will be more than justified.

Extras. There are two subjects which are very liable to cause controversy between builders and surveyors—extras, which there is no schedule price to govern, and day work. In the case of the former, when there is any considerable variation—such as, say, the substitution of wainscot for deal in a building, or any large addition to the contract—it is quite usual for the architect to get an estimate from the builder before ordering the work, a preferable method to leaving it to be settled at the end of the contract, and fairer both to the client and the builder. Where the variation is slight, and no estimate is given—and most contracts will show some few items for which there is no schedule price—compromise as to price ought not to be difficult. The usual method is for the surveyor to price out the extra and omission bills, and forward them to the builder for his approval. He may put the prices too low, anticipating that the builder will ask too much; but in most cases the builder will find himself able to accept as fair the prices offered, and will always find the surveyor open to conviction if he can prove that any particular item has been priced below its real value. For it is not the unfairness or partiality of a surveyor that the builder has to be on his guard against, but the ignorance that arises from knowledge gained by theory instead of practice. The writer has in mind one particular instance of this. The taking down of a door, casing, adjusting, and rehanging in the same position was priced by a surveyor at 1s. 3d. The builder would want 3s. for it; the surveyor might say that, theoretically, a carpenter should do the work at this price, but the builder would know from practice that not a carpenter could be found in London to do the work for 1s. 3d.

Day Work. But a more fertile cause of difference of opinion than extras outside the schedule price is the question of day work. There is not much difficulty about the actual prices—for, to most contracts there is a schedule for day work attached—but as to what kind of work a builder is entitled to charge under this head. Where the builder claims day work, the usual custom is for him to send into the architect weekly vouchers of the time and materials. Sometimes the architect will accept these outright, but more usually with the proviso that the surveyor must go into them at the conclusion and decide whether the work in question can be measured or not. Where there is a clerk of the works, he has to sign the weekly sheets; and where this is done, and the architect has accepted them, the builder should not forgo his claim to have this treated as day work; the surveyor has then no right to an opinion on the matter. But when, at the end of the contract, the day-sheets are handed over to the surveyor for adjudication, the builder must satisfy him as to the reasonableness of his claims. Some surveyors, unwilling to admit any limitation in their own profession, are too apt to think that any and every kind of work can be measured. Should the builder have the misfortune to meet such an one, he must make up his mind as to what he has a right to charge day work, and to insist on his rights. A builder's claim to day work may be based either on the nature of the work itself or the conditions under which it is carried out. Under the first head would come such work as the cutting away for hot-water fittings, unless the builder has to take the risk himself.

There is, for example, a provisional amount inserted for hot-water work, and sometimes the general contractor has to do the necessary cutting away for the fitters and to price the item as he thinks best; but more frequently there is a provisional amount also for the cutting away, and the builder returns what he does under this as day work. It is obviously impossible to measure a hole cut in one place and a hole made good in another. Under this head, too, would come alteration to work already done, such as alteration to drainage already laid. Where the day work claim is due to the conditions under which the builder has to work, it is advisable for him, before doing the work, to point out to the architect that he cannot do it at

the ordinary contract rate, always, of course, presuming that there is no clause in the contract to cover work under such conditions. Work of this kind would be, for example, that done to the interior of a school while in occupation of the children, where the builder has to do the work as best he can, and to suit the convenience of the teachers; and where the builder is not required by his contract to work under these conditions, he is quite entitled to charge it day work.

Excess and Deficiency. Before leaving the question of settling accounts, one other matter must be touched upon—the excess or deficiency of quantities. Bills of quantities can either form part of the contract or not. In the latter case the builder's claim, if he thinks there is a deficiency in some particular, would lie against the surveyor who had taken out the bills. Where the quantities form part of the contract, which is the usual course, the surveyor, when measuring up, will not raise the question of excess or deficiency, presuming that the quantities are correct, but will leave it to the contractor to make a claim if he wishes. But the builder will be advised to be very careful before he makes such a claim. Nowadays, quantity surveyors are scientifically accurate, and the contractor, unless he should discover any considerable omission, will not find it worth his while to raise questions on small points which, while involving much labour, will bear little practical fruit. In this matter the builder will do well to restrain the zeal of his foreman. Many foremen, when a job is being measured up, are eager to point out that the quantities are short in this or that particular, without, of course, having gone into the general question whether it is worth while to raise the question of quantities, and a foreman should always be advised to refer such points for the contractor's consideration and decision. One other point the builder must be prepared to meet—the accuracy of his own prices in the bills. This will arise only in the case of extras and omissions. For example, suppose there is an amount of galvanised iron tongue in the bills taken out per foot run, priced by the builder either in ignorance or mistake at 1s. 6d. per foot instead of 1½d. On the completion of the job there is found to be a large quantity extra, and the surveyor will wish to price this quantity at the usual price. The builder must here stand firm—the bills of quantities form a schedule that must not be departed from, whether the error is in his favour or not. If it had been against him, the surveyor would have shown no mercy. Of course, in some cases, errors of this kind are detected, when the builder deposits his priced-out copy of the bills with the surveyor, and in that case he is asked to correct the error without, of course, altering the total of the contract sum.

Outside Work. It remains very briefly to consider the work that a builder has to do in supervising and managing the contracts he has in hand. This side of his work, though second in importance, can be by no means lightly regarded. The great quality he will require, whether dealing with the client or the architect or his own workmen, is the quality of tact. Personality tells here more than on the other side of his business, and the possession of tact may make all the difference to the keeping or losing of a connection. The jobs on hand should be visited frequently, so that the builder may see for himself that satisfactory progress is being made, and that if any difficulties arise he may have immediate knowledge of them. One of his most necessary equipments will be a thorough practical knowledge. Questions may arise any day as to the best and safest way of carrying out his work when the knowledge of his foreman will need to be supplemented or corrected by his own. The foreman may be inclined to sacrifice safety to speed, and needs at times a restraining hand in this direction. The architect may require advice at times as to the best construction to be used, and though, should anything happen to the building through faulty construction, the first responsibility is the architect's, the builder would not be guiltless of contributory negligence if through ignorance or carelessness he had failed to see what was amiss. Then the builder should have some acquaintance with the Building Acts and the various bylaws of the central and local authorities. The responsibility of meeting their requirements is always thrown upon his shoulders, and his task is not rendered any more easy by the anomalies and inconsistencies of which they are full. His more immediate duty on his visits will be to see that the jobs are being kept well supplied with materials. In this matter he should be very careful to look ahead. Foremen are too apt to imagine that if they give an order it can be executed the next day: but the builder who waits for his foreman to order the material will find his jobs standing still for lack of them, and it often means that, while waiting, men have to be taken off from one piece of work and put on to another—a very ready way of mounting up the cost of a job.

Defective Materials. Then he will be sure at times to have to deal with the question of bad material. He will come round to his job one day to learn that the clerk of the works has condemned the bricks or timber as not being up to specification, and he will have to determine promptly by personal inspection whether the clerk of the works is justified or whether he thinks the material good enough to defend. In the case of bricks it is usual to deposit with the architect at the beginning of a job a fair average sample of the bricks to be used, and by this sample the builder should bind his brick merchant, ordering his bricks from it. This course allows a fairly wide latitude, for bricks must be judged in the bulk, and what the builder has to determine is whether the bricks condemned have been so because of a few bad ones among them, or because they are a thoroughly bad lot. In the latter case he is without defence, and he will be well advised if he has one load of bricks condemned to warn his foreman not to take in any more of them on the job unless they are up to sample. His position with the brick merchant, if the bricks are really bad, will be much stronger if he refuses to have them unloaded.

The question of timber will be a far more difficult one. It is usually specified to come from certain ports—in some cases, even, from ports whence timber has ceased to be imported for several years. The builder's best course is to inspect the timber in the docks before he buys it, and satisfy himself that it is up to his requirements. But really good timber is getting scarcer and dearer every year, and he will often have to be satisfied with the second best. If his timber is condemned and he is convinced that he cannot defend it, his best course is to take it off the job at once. That is not to say that he is always to give in. He may have the misfortune to meet with a clerk of the works who has a passion for condemning everything both in material and workmanship, and who thinks that it is his function to hinder rather than to help a job.

Speed of Work. But above all, the builder should carefully watch the progress of his jobs, and see that he is not getting behind his contract

time. It is true that penalties for time are rarely enforced, because there are so many contributory causes of delay—besides, possibly, the builder's lack of energy—that enforcement is found impossible in practice; but, in any case, slow work in these days is bad for the builder's reputation, and his pocket. It is a matter for discussion whether buildings were not better built when they were erected calmly and without hurry than they are in these days of rush. But the builder to-day has no time to stop and discuss this; he must move with the times, or he will soon cease to do building at all. But while taking care that his jobs are being pushed on as rapidly as possible, he must see to it that they are not crowded with men, or his cost book will be anything but pleasant reading. Besides his ordinary visits the builder should make a point of sometimes visiting his jobs at the time of starting in the morning; foremen want keeping up to the mark in the matter of time, and a late foreman means no work done before breakfast.

Foremen. The choice of the right men to carry out his work is a matter of great importance to the builder, and very much depends on the foremen he employs. The chief requisite in a foreman is the capable management of men; he must not only have a first-rate knowledge of the best means of carrying out work, but he must also be able to drive his workmen and get the most out of them he can, consistent with safe construction; and for this reason a foreman should be allowed a free hand in the choice of his men, with a few obvious limitations. Should a man be taken on at a job whom the employer, from previous experience, knows to be a bad workman, the builder must, of course, tell his foreman that he cannot have the man on his works; but apart from such exceptions the builder should not interfere with the men the foreman chooses, and if he has cause to feel dissatisfied with the men employed on the job, and should the results convert that feeling into conviction, the only way is to get rid of the foreman. It is almost unnecessary to say that a foreman must be sober and honest, straight not only to his employer, but to his employer's clients. A man who is dishonest towards the clients will, in the end, be dishonest towards his own employer. A builder should see that he makes his own interests and the foreman's identical; this can be assured by giving the foreman continuous employment, and keeping him on even if for the moment another job cannot be found for him. Another method by which a foreman can be induced to take a serious interest in his work is by offering him a bonus at the end of the job should it come out on the right side; but this wants careful consideration, and special care should be given to the foreman's character if this bonus is offered. In these days of cutting prices, where work is too often taken below cost price, it is a temptation to a foreman to make the job pay by scamping the work. How far should a foreman be trusted is a question that builders are always having to put to themselves. Should a foreman be allowed to pay wages himself, or ought it to be the invariable rule that somebody from the office should pay? In the case of small contracts, where the wages are not heavy, the foreman may be trusted to pay, but only, of course, provided that the builder has had him in his employ for some time, and is convinced of his trustworthiness and honesty. But with contracts of any size, it is the rule for the builder himself or a clerk from his office to pay at the job. One other piece of advice may be useful—don't sack your foreman for trivial reasons. The old-fashioned method was to send a man away at once if you had the slightest disagreement with him; that method is happily passing away, experience having proved that a man who is always in fear of dismissal does not make a good servant.

Employer and Workmen. The decay of such methods of dealing with men, accompanied as it has long been by the growth of trades unionism and combination of both masters and men, has had as its result the development of better feeling between employers and their workmen. The master has come to recognise that men are entitled to a fair wage, and the men that the builder is entitled to a fair day's work in return. It is not too much to say—speaking for London—that the best builders are to be found in the membership of the Master Builder's Association, and the best workmen in the various trades unions. The strength of these two combinations has led to a mutual respect on both sides, and reduced almost to a minimum the danger of strikes.

The Attractions of the Building Trade. It may, perhaps, be asked, can building, under modern conditions and modern competition, be made to pay? Reasons have already been given for thinking that the present depression is but temporary, and in that belief the wise builder will bide his time. It ought to be an axiom, but is not, that no builder should take work below cost price, and if for the time he finds it impossible to compete with modern prices, he had better hold his hand. It is better to play in the streets than work at a loss, and continual lowering of prices will tell its own tale in the Bankruptcy Court. Let him keep his head, get what little work he can at a fair profit, and not plunge by taking large contracts at impossible prices.

With all its drawbacks one charge cannot be brought against the building trade—lack of interest. At the end of most careers a man can only point to the amount of money he has made as evidence of his work; the builder leaves a far more enduring mark behind him, and though not, of course, sharing the artistic honours that fall to the architect, he is essential to his work, for without him the architect's ideas would find no permanent or concrete expression. For this reason, to say nothing of others, no builder who honours his business should consent to have anything to do with scamping methods or to take work at so low a price that no profit can be made without seriously deviating from fair workmanship. And here architects may well be asked to lend a helping hand by refusing to hold out to their clients delusive hopes as to how cheap work can be done.

BUILDING ABROAD

In the details of building operations and methods there is room for much diversity, and practice is regulated by climate, custom and materials.

This course has of necessity in considering the detailed methods of building construction dealt with their execution as carried out in England. To a great extent, in many of the trades the practice is much the same in the whole of Greater Britain and America, and either an architect or a builder who had received an efficient training in his own country, though he would find—especially in the details of practice—divergencies from what he was accustomed to, would, in a very short time, readily adapt himself to them.

Effect of Climate. In many of the great English colonies the climate is essentially different from that of the mother country, and the result of this difference is frequently that buildings of a

different type altogether from those erected here are required, and the disposition of various parts of a building have to be modified to suit the changed conditions. This is particularly the case with the humbler class of buildings, in which the desired result must be arrived at without any great outlay, and in which, on this ground, purely local materials must be employed and used to the best advantage. The more undeveloped any country or district is, the more primitive will be its buildings, and where entirely new ground is broken the settler must often in the first instance be his own builder and construct his log cabin in a rough and ready fashion.

But as soon as communities collect together, building passes into the hands of a special set of people who have had special training or show special aptitude; but so long as the community is somewhat isolated and difficult of access, the nature of the material to be obtained locally will greatly influence construction, and the best builder will be he who can apply them best.

Means of Transport. Transport, both by rail and from the nearest station by road to its destination, is in many newly-settled countries costly; as a consequence, when materials are brought from a distance, those that are comparatively light are sought for, and are employed, even though they are by no means the most suitable ones that can be used for the purpose. An instance of this is the very general use of corrugated iron as a roofing material in South Africa; it is unquestionably as light a material as can well be employed for this purpose, but, apart from the difficulty of giving it any artistic treatment, it is on many grounds unsuited for use in such a climate; yet its cheapness and the facility with which it may be transported has brought it into very general use, not only in South Africa, but in other colonies where good roofing materials are not produced. The element of cheapness is one that in all countries or districts that are not highly developed is usually an all-controlling factor.

A dwelling must be provided, but it must be inexpensive, and therefore without many of the comforts and even what are considered necessities in more advanced districts, and in such cases it is naturally the work in the finishing trades that is omitted. The walls and roof are essential and cannot be omitted, but such matters as internal plastering and plumbing work very often must be sacrificed in such circumstances.

Materials and Design. In a very considerable proportion of newly-settled countries wood is the most readily available building material, and, except in extremely isolated cases, sawmills are usually established early and convert the timber as felled into the various forms required by both carpenter and joiner. Wooden buildings are very largely used in many such districts and often continue to be employed long after other classes of building materials are available. Such structures are often carried out on a large scale, and in Australia, for example, and in America also, houses of considerable size are to a great extent constructed of wood in suburban and country districts.

Australia is well supplied with good timber, and hard woods are largely used in house construction, though imported woods are also used for some classes of work. The usual construction is that of a timber frame with head posts and sills, well braced, and covered externally with stout weather boarding and plastered or lined with boarding internally. Such buildings are most easily constructed as one-storied buildings, and as land is of comparatively small value in such districts the large area covered by such a building is not a serious drawback; in such cases any heavy framing can usually be avoided. And buildings of this type also lend themselves to the provision of wide verandahs, a feature welcomed in countries where the sun has great power.

The Influence of Custom. Such a verandah is a feature in the life of many of the colonies, and is commonly met with in Australia and Africa for instance: the type of building arising in such cases from the exigencies of the situation, in the first instance, is apt to be confirmed and continued when the necessity for the original methods of construction, which produced them, has passed away. In Australia, beyond the towns and in country situations houses of considerable size and value are constructed as one-storey buildings sometimes in wood, but sometimes of more permanent materials.

The influence of custom and tradition is always strong, and a type of building that has been produced to meet the needs of a locality is apt to be improved and developed, but not altogether lost sight of when somewhat more complex structures are required. On the other hand, in the case of buildings of a class which cannot be erected until a community has become highly developed, such as large public buildings, banks and churches, the traditions of the mother country often, to a very great extent, regulate their design and development, influenced in detail by local requirements as to construction, but similar in general treatment to the same class of buildings as used in the older European countries. Within the limits of the same country, especially if it is of great extent, varieties of climate and other conditions will arise which will lead to modification of any general type, much as in Europe such differences have led to the use of buildings for the same purpose but wholly different in character in the extreme north and south, for example, though in Europe these variations are further influenced by difference of race.

But in a country of even moderate size, especially in the case of countries which have to depend largely on imported materials, those towns which lie on the coast or are directly served by a railway will have a great advantage over those less well served, and this is particularly the case with all those coast towns that become ports. The necessity for handling building materials when they are transported by different kinds of conveyances—from a ship to a waggon, thence to a train, and again to a waggon—make the cost of dealing with them very heavy where several such changes have to be made; in a seaport the cost is often greatly reduced by the possibility of conveying goods direct from the ship to the site.

When a country is so far developed as to be able to depend to a great extent on its own resources for all kinds of fittings as well as for the materials of the carcase work, this special advantage is less marked; but even in countries that have been settled and developed for a long time, a considerable number of fittings and special appliances are almost always required to be imported.

The Rapid Growth of Towns. One of the surprising features of many of the important cities in the Colonies and America is the extraordinary rapidity with which they arise in what has hitherto been little more than a wilderness. A discovery of gold, or some other cause, attracts people to a centre, where buildings of a simple

character are at first hurriedly constructed; but in a surprisingly short time the original settlement is replaced by a well laid out and well constructed city, which almost immediately springs into life and full activity.

In some respects such a city possesses great advantages over many of those in older countries, as from the very first its disposition and general development can be regulated without interference with private and vested rights, such as prevented the adoption of the magnificent scheme for rebuilding London prepared by Sir Christopher Wren after the Great Fire. It is true that most towns of this class lack, and will ever lack, the picturesqueness and charm of an old world town, with its streets of irregular width and varying line; but from the purely business point of view the orderly laying out of a town on a definite plan, designed to facilitate communication between all its parts by spacious streets, is of great commercial value. Such a disposition is not necessarily incompatible with the arrangement of fine street architecture, as is evidenced by Wren's plan already referred to.

Tall Buildings. One of the striking developments of the new American cities is the enormous height to which buildings are carried up, in a manner which in this country, with its old laws as to easements and the rights of neighbouring owners will fortunately never be possible. The possibility of erecting such structures, to which, in New York, for instance, there seems to be hardly any final limit, has undoubtedly led to the development of a system of construction different in character to any developed under more reasonable requirements. Such buildings are only possible when executed, so far as their main structure is concerned, practically exclusively of steel. It would be impossible to carry up a building of 20 or 30 storeys, or even more, in height with walls of either brick or stone without making the lower walls of such immense thickness, and the whole building of such an intolerable weight, as to defeat its own object.

Special Methods of Construction. With a steel frame, however, the conditions are altered, and though the total load on the foundations will still be enormous, it is possible, by skilful disposition, to distribute this over a very large area of surface, and to erect structures extending to upwards of 300 ft. high and of many storeys, enclosed with walls which are mere screens against the weather. The walls of each storey are carried on girders independently of the storeys either above or below, so that it is possible in such a building, after the frame is once erected, to start the walls at any level without the necessity of building them up in the ordinary method from a solid foundation. In our own country steel-framed buildings are becoming common, but in London, at least, the regulations do not permit of American methods being carried out to the extent of treating each storey as an independent wall, and regulating it as regards thickness on this basis; this is, however, an essential feature in the success of such a system of construction, if full advantage is to be taken of its possibilities.

The foundations for such lofty erections must be prepared with great care; this is a matter of even greater importance than usual, when such enormous loads are to be carried, and in America piles are used almost invariably, not merely placed in rows under lines of wall, but very usually disposed in a series of lines over the whole area of the site; they are finished with a timber grillage and concrete, as already described. When once, however, the preparation of the foundations is completed the work of the superstructure can proceed with great rapidity; the erection of the steel frame, which may be prepared while the foundations are being put in, being by no means a lengthy operation. When once this is completed the filling in of the walls may be carried out at several different stages at one and the same time.

The erection of such lofty buildings does not merely affect the manner in which the carcase is erected, but all kinds of internal details—such matters, for example, as those of water supply and the means of access to the upper floors, which is usually arranged for by means of express lifts. The problems of heating and ventilation also require special consideration and treatment in such lofty structures.

Labour-saving Plant. In the great towns of the North American continent the builder and contractor is often better equipped than in this country with all kinds of labour-saving plant, and, as in the case of many other industries, many of the machines and appliances now in use in other countries have been originally invented in America to facilitate rapidity of construction.

It is largely the desire for extreme rapidity of construction that has led to such modifications as have been referred to in building methods, combined with the desire to reduce to a minimum the area of the supporting and enclosing walls, so as to render every possible inch of a site available for use for the purpose of bringing in rents. This is largely due to the immensely increased value of land in the larger and more important towns, and with such inflated ground rents it is naturally important to secure that as large a proportion as possible of the area shall earn rent; it is also important to ensure that the site shall lie idle for as short a time as possible.

All such work requires the most skilful organisation and forethought; it does not suffice for the contractor to look forward for a few days and weeks, but he must from the very first look forward and arrange for all the work that will be required to complete his building.

Drawbacks of Rapid Construction. This hasty building, the outcome of commercial pressure, is not without its very serious drawbacks. It gives no time for the thoughtful consideration of the architect's work, which, like the builder's, must be turned out as it were from a drawing machine. Buildings designed and erected under such conditions must, almost of necessity, bear a commercial rather than an artistic impress. Really good architectural work must have time and consideration given to it for its careful development, and hasty planning, and the impossibility of modifying in any way a design while the work is in progress, militates against the best work.

The system has this great disadvantage, too, that it creates a general impression that all work can be carried out at a much quicker pace than is desirable, except for such special structures as have been described. It is, however, fatal to really good building to hurry it unduly, for work requires to be given time to settle into its place; if walls, therefore, are rushed up hurriedly, too great a load may be placed upon the lower portions before the mortar is properly set, and the building is not given time to dry before the finishings are put in, resulting in shrinkage and other evils.

Effect of Climate on Individual Trades. It is not possible to deal in detail with the effect produced on the different trades by variations in climate in various parts of the world; it may be desirable, however, to point out that this is a matter that does affect methods of work and the possibilities of applying certain classes of materials, and creates a class of conditions which affect certain trades in a manner totally different from those with which we are familiar.

One or two examples may suffice to draw attention to this point. In some hot climates, for example, the plasterer has not to guard against his work being damaged by frost at certain seasons, but he may have to fear the effect of hot drying winds that will most injuriously affect the plaster; it may be just as important to suspend work at such times as with us in frosty weather.

Great heat and rapid changes of temperature, such as occur in some places, render the use of lead on roofs, and even for pipes, very undesirable, owing to the amount of expansion that is caused, and the increased tendency to "creep." In such climates, substitutes have to be provided, and in many similar ways the details of various trades must be modified and adopted to suit local conditions.

Again, in some places, the ravages of insects, such, for example, as the white ant, are so serious as to require special conditions to meet them.

The builder abroad may, in many districts, have a much greater difficulty in finding the men he wants, skilled in the various trades, to carry out urgent and important work, as the supply is often limited. The management and control of men under such conditions is one of greater difficulty than when the supply is greater than the demand.

The qualities and powers, however, that make a man successful as a builder in one country will be useful in another; and he who has had a thorough training, and has this capacity for controlling and directing labour and the complicated work in a variety of trades and managing the business of a builder's office, will not find the variation of any local conditions so great that these cannot, with a little time and attention, be thoroughly mastered and overcome if circumstances make it desirable that work should be taken up in other lands than that in which he has been trained.

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Continued

Group 26 BUSINESS MANAGEMENT 1 Following SHOPKEEPING from page 6212	BUSINESS CORRESPONDENCE The Business Letter. Punctuation. Composition. Forms of Address. Value of Shorthand. Tuition

BUSINESS CORRESPONDENCE

The Business Letter. Punctuation. Composition. Forms of Address. Value of Shorthand. Tuition

THE term "Commercial Correspondence" includes the whole system of conducting business transactions by means of writing. Its great importance consists in the fact that it brings into communication people far distant from one another, and helps to establish the closest business relations between them. Thus, the trader in London, by means of correspondence finds scope for his activities over the whole globe. By far the greatest part of the trade of the world is obtained and carried on by means of letters. With the rapid extension of postal and cable facilities the opportunities for business are also extended, and with them the province of commercial correspondence.

Confirmation of Verbal Agreements. Moreover, it is the rule in business to confirm by letter any verbal agreement entered into. In fact, according to the Sales of Goods Act, 1893, a contract concerning goods to the value of £10 or upwards *must* be made in writing, or it will not be enforceable by action at law.

It is obvious, too, that a letter, as a vehicle of communication, possesses advantages which are particularly useful in cases where extreme caution is necessary in the use of words. We may be led to utter a hasty word in an interview, or to make an admission that will be regretted later; but in a letter we can say exactly what we desire to say, neither more nor less, and we can consider the import of our words and their effect before the communication is despatched.

It is clear, therefore, that the ability to write correct commercial English should be carefully cultivated by business men in whatever capacity they may be engaged. That this ability is not so general as it ought to be is matter of common knowledge to all who have to do largely with business correspondence, and the object of this article is to assist those who seriously desire to acquire a qualification which is absolutely necessary if mistakes and misapprehensions in the conduct of business are to be avoided.

Everyone has a perfect right to make his own style of letter writing, and, as a rule, the more characteristic it is of the writer, the better; but custom has established certain forms and usages for business correspondence which it is generally convenient to follow. Accordingly, a letter is usually divided into parts.

Parts of a Letter. A business letter may be divided into six parts, as follows: (1) The heading; (2) the inside address; (3) the salutation; (4) the body of the letter; (5) the complimentary close; and (6) the signature. These parts should follow one another in the order here given.

The *heading* should consist of the postal address of the writer, with the date of writing and, in some cases, a reference letter and number for the purpose of classification. The parts of the heading, the street, town, etc., should be separated by commas.

The *inside address* should give the name and address of the person or firm to whom or to which the letter is written, and it should never be omitted, since a press copy of a letter without the name and address of the person to whom it was written would be of little value for reference, and of no value as evidence. The inside address should be punctuated in the same way as the heading.

The *salutation* is the "Dear Sir" or other complimentary term used to begin the letter, and it should be followed by a comma.

The *body of the letter* is the part which contains the message, the inquiry, or the information to be communicated, and it is, of course, the most important. The writer should take care to leave a sufficiently wide margin at the left-hand side of the page, and should see that all lines except new paragraph lines begin exactly at the same distance from the edge of the sheet. It is not practicable to arrange a regular margin at the right-hand side of the paper, but the termination of the lines should be kept as uniform as possible by judicious spacing and the careful division of long words. The writer should also leave ample space for the complimentary close and signature. There is nothing more distasteful than to see the formal ending of a letter and the signature occupying a space by themselves on a separate sheet and more or less detached from the rest of the communication. A business letter should never be written on both sides of a sheet. Where the communication is too lengthy for one sheet, use others and number them consecutively. The punctuation of the body of a letter should follow the rules which apply in the case of ordinary printed matter. A few general directions on the punctuation of business matter are given later.

The Close of a Letter. The *complimentary close* consists of the words of respect used to express the feelings of the writer towards his correspondent. The terms used should always be consistent with those employed in the salutation, and the words should not be abbreviated. For example, "Yrs. ffy" should not be written for "Yours faithfully." It should be noted, too, that a capital letter is necessary in the *first* word only of the "Yours faithfully" or other term employed.

A concluding sentence such as *Trusting you will give this matter your careful consideration* should begin a new paragraph; the term *We remain*, or whatever words may be used in this connection, should be placed on a separate line, and preceded and followed by a comma; and the complimentary close should be placed on a line by itself.

The *signature* is the name of the writer or of the firm he represents. It ought not to be necessary to say that the signature should be a perfectly legible one; but experience proves that there are many persons who adopt a style of signature that can only lead to uncertainty in the mind of their correspondents who are strangers to them. Intricate and absurd flourishes are employed by many in the mistaken notion that such signatures are difficult to imitate. As a matter of fact, the exact contrary is the truth. The plainer the signature, the more difficult it is to forge it successfully. Where the writer of a letter is a woman, and a reply is expected, the signature should be preceded by the title *Miss*, or *Mrs.*, in parentheses, in order that the reply may be properly addressed.

A word of warning may be added against the foolishness of constantly changing the form of signature. A sensible business man adopts a form and sticks to it.

The signature should be written on the line next to the complimentary close, and should be written so as to finish near the right-hand edge of the paper.

The manager or secretary of a public company usually adds his official position when signing: thus, *William Church (Manager)*, *Henry Winton (Secretary)*. Strictly speaking, only a partner in a firm is entitled to sign the name of the firm: but, in most houses of business certain employes are also empowered to sign the firm's name. This authority is often given by means of a legal instrument called a power of attorney, and it is usual to publish the names of persons so authorised, or to send copies of their signatures to the correspondents of the firm. These persons are said to sign *per procurationem*, which means power to conduct another person's business, and. therefore, to sign letters, etc., on his behalf. *Per procurationem* is contracted as follows: *per pro.*; *p. pro.*: or *p. p.* For example:

p p. Smiles & Co., or *per pro. Smiles & Co.,*
Charles Locke. *Charles Locke.*

There is no commoner mistake made by junior clerks than to sign an unimportant letter or post-card given them to despatch with their name, preceded by an abbreviation for *per procurationem*, when, as a matter of fact, they possess no such authority.

An employe having no special power to bind the firm should sign as in the following example:

for Smithson & Co., or *pro Smithson & Co.,*
Edwin Reed. *Edwin Reed.*

Characteristics of a Good Business Letter. These are (1) absolute accuracy and clearness as to the facts, figures, or terms referred to; (2) brevity, so far as this may be retained along with clearness of meaning; and (3) courtesy, which is at all times advisable and always possible, even in a letter which is otherwise disagreeable to the recipient.

The business correspondent, therefore, should make it a rule to see that all quotations, terms of delivery, etc., are carefully checked before a letter is despatched. No trace of ambiguity should be present to make it possible for even the most ingenious person to extract two meanings from a communication. It must be remembered that the recipient of a letter will naturally construe it in the sense most favourable to himself, which *may* mean pecuniary loss to the sender of the letter. The business letter writer should make every effort to acquire the ability to express himself clearly and concisely, and to adopt a courteous tone in both writing and speaking, even when he is most firm in his attitude, on a matter of business.

Excellence as a business correspondent can be acquired only by careful study and much practice, but the beginner will derive considerable benefit from the perusal of the specimens of actual business letters given in "Pitman's Commercial Correspondence and Commercial English" (Sir Isaac Pitman & Sons, Ltd., London), which also contains a long chapter of instruction in this necessary art.

The Arrangement of the Letter. A logical order and arrangement of the various points treated should always be observed in a business letter. It is a mistake to refer in the third and fourth paragraphs to a matter which is dealt with in the first paragraph. All that requires to be written about any subject should be written in the same part of the letter, and not scattered here and there throughout the communication. Loose writing indicates loose thinking, and gives the correspondent a poor impression of the writer.

Excessive Paragraphing Should be Avoided. It is sufficient to begin a fresh paragraph when there is a change in the subject. In letters between a firm and its agent it is usual to indicate the matter dealt with in each paragraph by writing at the beginning some word or words which serve as a sort of title to the paragraph. This greatly facilitates reference to any point in the letter, and the method is accordingly growing in favour.

Punctuation of a Business Letter. Punctuation, or the insertion of stops in correspondence, is necessary to mark the parts and sections into which sentences and paragraphs are divided, so that the exact meaning may be quite clear. The real use of stops is to cut off and separate single words, or groups of words, from one another.

The ability to punctuate properly can be acquired only by a fairly extensive course of reading of the best authors and a considerable amount of practice in original composition. The reading and copying of high-class poetry will be found of great assistance in the acquisition of the knowledge of the correct use of stops.

It should be remembered, however, that the more carefully the matter is arranged and written, the less need will there be for punctuation marks. It is a mistake to depend entirely upon punctuation for the correct interpretation of a passage. Moreover, an excessive use of stops gives a broken appearance to the matter, and may lead to confusion. After all, punctuation is largely a matter of individual taste and discretion, and depends to a great extent upon the style of the writer and the subject of the composition. The following brief hints with regard to the use of stops in the composition of business correspondence may be found serviceable to the beginner.

The Full Stop (.). This mark is used: (*a*) at the close of a sentence, as: *The goods were forwarded by L. & N. W. Ry.* yesterday. (*b*) After abbreviations, Roman numerals, and headings, as: *G. Goodman, Esq., B.A., The Laurels, Ealing, W.*; *Chapter XV.*; *Service Regulations.*

The Colon (:). This is inserted before a remark which is of the nature of an afterthought, as: *Invoices to be sent direct to customers: copies to me at this address. Please see that the pattern is copied exactly: mere similarity will not do.*

The Colon and the Dash (:—). These are used before a quotation or a list of things, as: *Referring to your inquiry about Mr. Thomas Thowell, we have a letter from our agent this morning in which he says:—"I have made careful inquiries re Mr. Thomas Thowell, and I find that he failed in* 1901, *with liabilities* £3,500, *and assets* £275." *Please quote us your lowest prices, F.O.R. Liverpool, for the following:—*

15 *cwt. Mysore coffee*
7 *cwt. Trinidad cocoa*
5*-ton lots best cube sugar.*

The Semicolon (;). This mark is employed when two or more sentences are combined, as: *I called there to-day; saw the buyer; and secured the order which is enclosed herewith.*

The Comma (,). This is used: (*a*) when it is necessary to indicate a short pause so that the sense of the passage may be quite clear. as: *Upon the*

receipt of your cable of the 10th inst., I called upon Messrs. Deane, who practically control the market at present, and asked them to alter their quotation; but they absolutely declined to budge a cent.

(*b*) When it is desired to separate a parenthetical clause from the remainder of the sentence, as: *If this trial order gives satisfaction, as we have no doubt it will, a profitable business may result, since our friends do a larger trade than any house in this particular market.*

(*c*) Before and after words the insertion of which slightly affects the smoothness of a sentence, as: *Kindly examine the account, and, if correct, be good enough to send us a cheque for the amount at once.*

(*d*) Between two phrases joined by the word "and," as: *We should be pleased to have your orders again, and we feel sure you would be satisfied with the quality of the goods we are now offering.*

The Dash (—). This mark is used to denote an abrupt break in the sentence, or it may take the place of brackets, as: *Referring to the consignment of hat trimmings—which, by the way, we are expecting daily—we have got into touch with several likely buyers, and we hope to effect speedy sales at fair prices.*

The Interrogation Point (?). This is used: (*a*) after a direct question, as: *May we send you a small parcel at this price?* (*b*) At the end of a sentence which is meant as a query, as: *We presume you would have no difficulty in making delivery of the goods by that date?*

The interrogation point is *not* necessary when the question is only reported to have been asked, as: *I saw the chief traffic manager, and he asked me when we could supply the necessary details.*

The Apostrophe ('). This is properly used (*a*) to mark the possessive case of nouns, as: *We have forwarded you to-day, per M. Ry. Co., a case containing 6 dozen men's caps, 4 dozen boys' vests, and 3 dozen girls' Tam-o'-Shanters. The manager's clerk called at the company's office yesterday, and was shown Mr. Boyd's receipt for the correct amount. We completed Mr. Evans's order last week.*

(*b*) To indicate that some letter or letters have been omitted, as: *I don't think it's possible to do anything with this man. I can't arrange an interview with him, as he won't even answer my letters.*

(*c*) To indicate the plural of single letters or figures used as words, as: *Your correspondent must mind his p's and q's. All the 2's and many of the 4's are faulty.*

The Quotation Marks (" "). These are used (*a*) when the exact words of another person are quoted, as: *Please note that our bill of £260 10s. 6d., due on the 2nd inst., has been returned to us marked "Refer to Drawer," and our bankers inform us that your account is overdrawn. The exact wording of the clause was as follows: "If loaded in the Danube otherwise than at Salina, lighterage on the Danube or at Salina, if necessary, to be at merchant's risk, but steamer's expense."*

(*b*) When the titles of books, etc., are quoted, as *I asked his authority for the statement, and he told me he had seen it in "Pitman's Commercial Law," as well as in "Pitman's Manual of Business Training," and he was therefore satisfied as to its accuracy.*

It should be noted, however, that a quotation within a quotation is indicated by single marks only, as: *Mr. Walker said, "I charged him with trying to deceive us, and he answered, 'I am not. I will pay you in a week, or I will return the goods.'"*

Parenthesis Marks [( )]. These marks are used to enclose words or figures not strictly connected with the sentence in which they appear, as: *The cargo is to be placed on board in fifty running hours (Sundays and holidays excepted), to count from the time the vessel is ready to receive cargo.*

The Exclamation Point (!). This mark is not often used in commercial composition, but it would be correctly employed to express sudden emotion, surprise, etc., as: *Ten per cent commission! Ridiculous! The terms are absurd!*

Emphasis. Where it is considered desirable to emphasise words in a letter, a line is drawn underneath the words, as: *We wrote you on the 5th April, and again on the 12th April, with regard to our overdue account, and must now request your* <u>*immediate attention*</u> *to this matter.*

Use of Capitals. The following words should begin with capital letters:

(*a*) The first word of every sentence, as: *Please instruct your traveller to call. We trust the parcel will reach you safely, and that the quality of the goods will please you.*

(*b*) The names of the days of the week and months of the year, as: *Our representative, Mr. T. Kerr, will be in your town on the first Monday in June, and will call upon you as desired.*

(*c*) All proper names and adjectives derived from them, as: *James Beamish, Esq.; India, Indian; Harrison, Harrisonian.*

(*d*) Titles of persons, as: *His Excellency the Duke of Bragga Docio.*

(*e*) Titles of books as: "*Pitman's Mercantile Law*," HARMSWORTH SELF-EDUCATOR.

(*f*) The first word of every direct quotation, as: "*Pitman's Business Man's Guide*" *says* "*An executor may be appointed by name, or by implication; but, in the latter case, is called an executor according to the tenor.*"

(*g*) The pronoun *I* and the interjection *O*, as: *If you will give me a call, I shall be glad to arrange the matter. Knowest thou not, O stupid man, thy time is near?*

To those who desire to go further in the study of punctuation, we recommend "Punctuation as a Means of Expression," by A. E. Lovell, M. A., and published by Sir Isaac Pitman & Sons, Ltd. Price 1s. 6d.

Spelling. Inaccurate spelling is an unpardonable fault in a business correspondent. With the multitude of cheap and reliable dictionaries now available, there is no excuse for the habitually bad speller. Undoubtedly, many a young man has failed in his endeavour to obtain an appointment because of the grievous faults of spelling noticed in his letter of application. Faulty spelling is difficult to eradicate, because, as a rule, the culprit is not aware of his failing. The habit of referring to the dictionary in doubtful cases can be recommended as an almost certain cure for the worst offender. "Pitman's Pocket Dictionary" is a useful little work for the purpose. The following remarks may be helpful in preventing some gross errors, which are very common:

Their is a pronoun, as: *Their books have a capital reputation.*

There is an adverb, as: *There they were, stowed away on the shelves.*

Where is an adverb, as: *Where can we learn the system?*

Hear is a verb, as: *We hear they are in liquidation.*

Here is an adverb: *Here we met their traveller.*

His is a pronoun (also construed as an adjective), as: *We have read his book, but it is not his best.*

Is is the third person singular of *be*, as: *He is very clearly uneasy in his mind as to the result. It is certain that his influence is diminishing.*

Has is the third person singular of *have*, as: *He has seen the sample, and has satisfied himself as to its suitability.*

As is an adverb or conjunction, as: *As I have already stated, such a book as he has written cannot be as great a success as he has been led to expect.*

The correspondent will find it useful to keep within reach some such book as "Pitman's Commercial Speller" or the same publisher's "Pocket Dictionary."

Some Faults to be Avoided. A carelessly written business letter indicates a certain amount of disrespect to the recipient, which cannot be expected to lead to satisfactory business relations between the parties. Blots, erasures, repeated interpolations and corrections, as well as positively illegible writing, should be scrupulously avoided. It is infinitely better to rewrite a letter than to despatch it with disfigurements of the kind here mentioned.

Keep to Business. It is also a mistake to introduce purely private affairs, or matters of personal friendship, into a business communication. Your correspondent may not desire other persons to see the remarks of a private nature which you have inserted in your business letter to him. Yet how is he to prevent it if the letter follows the usual course, and is filed away by a junior clerk? It is, of course, easily conceivable that intimate private friendship may exist between persons having close business connections. But the relations ought to be kept strictly separate, as far as written communications are concerned.

Intemperate Language. Every business correspondent has had experience of awkward clients, persons whose peculiarities of temperament are evidenced in their communications in the form of ill-chosen and even rude expressions. The most even-tempered man is strongly tempted sometimes to write a hasty reply to a letter of the kind referred to. But the temptation should be resisted, and the answer allowed to wait, when calmer feelings and further consideration will probably suggest a widely different and much more courteous reply. A curt reply, dictated in a fit of temper, has been the immediate cause of many a closed account. A business man cannot afford to indulge in sarcasm at the expense of his customers.

Inaccurate or Insufficient Details. In letters ordering goods, asking for quotations, or inquiring with regard to non-delivery, etc., the writer should be careful to specify exactly what is wanted, or what goods are referred to. Such expressions as "Same as we had before" are more than likely to occasion unnecessary trouble and annoyance to both parties.

Abbreviations to be Avoided. The abbreviation "gents" for "gentlemen" is excessively vulgar, and should never be employed. The ampersand (&), while correctly used in the title of a firm, as: "Messrs Brown & Jones," should never be used in the body of a letter. It is also wrong to employ "etc." in the complimentary close. "Yours, etc.," should never appear.

Unnecessarily Long Letters. It is a mistake to write unnecessarily lengthy communications. Time is an important factor in a business man's life, and it is both impolitic and unfair to trouble him with a long letter when a shorter one would answer the purpose very much better. The author of "Letters of a Self-made Merchant to his Son" says that, "Beginning before you know what you have to say, and keeping on after you have said it, lands a merchant in a lawsuit or the poor-house, and one's a short cut to the other."

Some Hints on Business Composition. The late Sir Courtenay Boyle, in one of his lectures to business men, gave the following excellent advice: "If we write a letter (especially if it is a business letter). first of all we must be sure that we understand it ourselves. Then be sure that our correspondent will understand it. We ought to try to put ourselves in the place of the person who receives the letter—try to ascertain, as far as we can, that he will understand that which we wish to convey. Very often both rules are broken."

The correspondent should not sacrifice clearness to brevity—undoubtedly desirable as the latter quality is in a business letter. It is much better to write an extra sentence than to send off a letter which is in any way ambiguous. A very interesting as well as useful exercise for the cultivation of clearness of expression without verbiage is to take a paragraph from the commercial columns of the newspaper, and condense the intelligence there given into as brief a statement as possible, without using any unnecessary words. Or, as a variation, to take the leading article in the same paper, and delete every word which is not necessary to elucidate the writer's meaning.

Another useful practice is to write out sentences showing the distinction between words which are very similar in appearance and pronunciation, as: The new patent *calender* is mentioned in the *calendar*. He contracted to *alter* the steps of the *altar*. The *holy* man was *wholly* at fault in the matter. The lord of the *manor* has a disagreeable *manner*. The wife of the *sower* is a good *sewer*. *Whether* it hail, or *whether* it blow, the *wether* must *weather* it, *whether* or no. Please *check* the amount of the *cheque*, and, if correct, sign it.

Technical Terms and Phrases. There are certain technical terms and phrases familiar to every branch of commerce, and it is essential that the correspondent should have a thorough knowledge of those common to the business in which he is engaged. At the same time, he should exercise prudence in the use of these phrases when writing, and should refrain from using any phrase which he is not quite certain that the receiver of the letter will understand. Those who wish to possess a detailed list of the terms and phrases employed in business should obtain "Pitman's Business Terms and Phrases," which gives also an explanation of each phrase.

Forms of Address. The following are the proper forms of address to be used in correspondence. As business men have at least occasionally to write to ladies and gentlemen of title, the list has been extended so as to include the forms proper in such cases, as well as the correct manner of beginning and ending the letter:

A Prince of the Blood Royal.

His Royal Highness the Prince of Wales,
Sandringham.

Begin: *Sir.* End: *I remain, Sir, your Royal Highness's most humble and obedient servant.*

An Archbishop.

To His Grace The Lord Archbishop of York.

Begin: *Your Grace.* End: *I remain, my Lord Archbishop, Your Grace's most obedient servant.*

A Bishop.

The Right Reverend the Lord Bishop of Manchester.

Begin: *My Lord Bishop.* End: *I remain, my Lord Bishop, Your Lordship's most obedient servant.*

A Duke.

His Grace the Duke of Fife.

Begin: *Your Grace.* End: *I remain, my Lord Duke, Your Grace's most obedient servant.*

A Marquis.

The Most Honourable the Marquis of Ailsa.

Begin: *My Lord Marquis.* End: As in the case of a *Duke*, but using *Lordship* instead of *Grace.*

An Earl.

The Right Honourable the Earl of Cawdor.

Begin: *My Lord.* End as when writing to a *Marquis.*

A Viscount.

The Right Honourable the Viscount Gordon.

Begin and end as to a *Marquis.*

A Baron.

The Right Honourable Lord Acton.

Begin and end as to a *Marquis.*

Baronets and Knights.

Sir William Nemo, Bart. (or *Knt.*).

Begin: *Sir.* End: *I remain, Sir, Your most obedient servant.*

A Member of Parliament.

Joseph King, Esq., M.P.

Begin: *Sir.* End: *I am, Sir, Your obedient servant.*

An Official.

The Secretary,
Board of Agriculture,
4, *Whitehall Place,*
London, S.W.

The Right Honourable the Secretary of State for India,
The India Office,
St. James's Park,
London, S.W.

The Right Honourable the President, Board of Trade,
Whitehall Gardens,
London, S.W.

Begin: *Sir.* End: *I am, Sir, Your obedient servant;* or, *I have the honour to be, my Lord, Your Lordship's most obedient servant.*

Commercial Firms.

Messrs. Lorric & Sons.
The Spiegel Electric Co., Ltd.

Begin: *Dear Sirs* or *Gentlemen.* End: *Yours faithfully* or *Yours truly.*

A Firm Composed of Ladies.

Mesdames Buckley and Pearce.

Begin: *Ladies.* End: *Yours faithfully* or *Yours truly.*

A French Gentleman.

M. Pierre Dupré,
Rue Reaumur, 37,
Paris,
France.

A French Firm.

MM. Jacques Moet et Fils, or *Messrs. Jacques Moet et Fils.*

A German Gentleman.

Herrn Friedrich Werner,
Jäger Strasse,
Berlin,
Germany.

A German Firm.

Herren Weber & Cie.

An Italian Gentleman.

Signor La Cava.

An Italian Firm.

Signori Bocconi e Zanardelli.

A Spanish Gentleman.

Sr. Don Franisca Bermudez.

A Spanish Firm.

Sres. Selck y Cia.

Shorthand and Commercial Correspondence. A knowledge of shorthand is essential to anyone who desires to take up the position of correspondent in a business house; of course, the practically universal Pitman system is the one that should be adopted. It is a common occurrence for one writer in an office to be called upon to transcribe another's shorthand notes, and it is necessary, therefore, that all the shorthand writers in the office should employ the same system.

A proper study of Pitman's shorthand will be found a very valuable help to the study and mastering of foreign languages. The system has, in fact, been adapted to twenty different languages, including French, German, Japanese, Chinese, Spanish, and Welsh. There are numerous magazines and books published in Pitman's shorthand, so that the learner has a wealth of high-class reading matter always obtainable. The textbooks are cheap, and the study proves quite fascinating to thousands who take it up.

The Training of Correspondents. "Commercial Correspondence" is now a regular item in the curricula of day and evening commercial schools all over the country, and systematic instruction in this necessary branch of a commercial training is given by men who are not only qualified teachers, but also practical business men. The subject attracts large numbers of students, the majority of whom submit themselves for examination in the subjects at the close of the winter session, either by the Society of Arts or some other well-known examining authority. The examinations are eminently practical in character, the papers being set and marked by men actually engaged in commerce and having the conduct of business correspondence on a large scale. The preparation for the examinations must, therefore, be very thorough, or the candidate will find himself unable to pass.

Commercial schools under private proprietorship have not only increased during quite recent years, but they have developed their methods to meet the demands of the times. Many of these institutions now teach languages, bookkeeping, and other subjects of business training, by correspondence as well as orally, and large establishments like Pitman's Metropolitan School, Southampton Row, London, W.C. (the largest commercial school in the world), keep a special staff of teachers, who devote their whole time to postal tuition. There is, therefore, no reason why students who find it inconvenient to attend classes should not pursue their studies by means of postal tuition, secure in the knowledge that they will be guided by experts in the subjects in which they desire instruction.

A Final Word. In concluding this article, the writer would like to impress upon the reader the necessity, not only that he should be absolutely thorough in his devotion to the interests of his employer, but also that he should be possessed of a strong determination to do everything possible to succeed in life. The junior clerk—and even the office-boy—should cultivate a laudable ambition to become one day the senior partner in the firm whose service he enters; and he should fit himself by strict attention to duty, earnest study in his spare time, and absolute fidelity for the position which it is his ambition one day to occupy, realising the fact that the incompetent or lazy youth cannot become a successful business man.

Continued

WINES AND CIDERS

Fermenting the Must Expressed from Grapes. The Mystery of Bouquet. Wines which Do Not Pay Duty. Cider

By CLAYTON BEADLE and HENRY P. STEVENS

WINE is the fermented juice of the grape, for the production of which the vine is cultivated in the middle and southern parts of Europe, and also in other parts of the world, especially in California and Australia. The season for gathering the grapes will, of course, vary with the climate, but for some classes of wines the grapes are allowed to ripen more completely than for others. Thus, in the Champagne district the grapes are gathered before they are fully ripe, in order that the colour of the wine may be as pale as possible. On the other hand, for burgundy, the grapes are allowed to become fully ripe, in order that the deepest coloured wine may be produced. Leaving the question of colour out of account, it is probable that the best wine would be obtained from grapes fully matured, and allowed to remain on the branches as long as possible.

Expressing and Fermenting the Must. When gathered, the grapes are crushed [1]. In the case of white wines, it is not usual to remove the stalks, as the liquor is strained off immediately from the residue, and there is little danger of absorption of astringent matter from the stalks. For red wines, the stalks are invariably removed, as the skins (*husks*) are used later to colour the liquor (*must*).

The mechanism employed for removing the stalks consists of a series of sieves. The grapes are crushed either by treading or by passing between rollers, and then passed to the press. The old form consisted of a box with perforations, through which the must was expelled, pressure being applied by a plunger worked by a screw; but this form of machinery has been largely replaced by centrifugal machines.

The next process consists in fermentation of the must, which is brought about by the albuminous matters it contains. For white wines, the operation is conducted in covered vats, provided with a hole in the cover to allow the escape of carbon dioxide.

Red wines are usually fermented in open vats in the presence of the husks, the whole mass being stirred from time to time. In this way much of the colouring matter is taken up, and the bouquet improved. In the course of the operation, which lasts from twelve to fourteen days, the yeast cells settle to the bottom, carrying with them most of the albuminous matter. The "young" wine is thus drawn off, and allowed to settle in other vats. When this second sedimentation is complete, it is drawn off into clean casks and allowed to mature. White wines are liable to a second fermentation if the albuminous matter is not completely removed with the yeast; but this does not happen with red wines, as the tannin and acids extracted from the husks prevent any further fermentation. In the process of maturing, the young wine loses any sugar it still contains by such after-fermentation; at the same time, albuminous substances and colouring matters separate out, together with acid potassium tartrate, as a crystalline crust, known as *argol* [see APPLIED CHEMISTRY, page 4782].

Before fermentation grape juice contains varying quantities of sugar and acids. From analyses that have been made, we may cite the case of must from the Rhine district, containing about 18 per cent. of sugar, making, with other extractive matters, 24 per cent. of total solids, which include albuminous and inorganic salts and 0·6 per cent. of free acid.

The chief products of fermentation are ordinary alcohol and carbon dioxide gas; in addition, there are formed small quantities of glycerin, acids, complex alcohols, and ethers, to which the bouquet of the wine is largely due.

Natural wines fermented from the unadulterated must contain from 6 per cent. to 12 per cent. of alcohol, and glycerin to the extent of from 7 per cent. to 10 per cent. of this quantity.

Flavour and Bouquet. The question as to the bouquet of wines is of the greatest importance from a commercial point of view, and much work has been done with a view to ascertaining the cause of the flavour and the means of producing it. In some cases it has been stated to be due to the action of frost on the grapes. It is also affected by the matters extracted from the *marc* (husks, stones, etc.), by the fermented juice. It appears, however, that it is possible to obtain the flavour in the case of inferior wines by the use of pure cultures of micro-organisms, obtained from high-class vintages.

It is stated by some observers that yeast from one district will produce a wine with the bouquet characteristic of that district in a must from a different source. Pasteurisation and special cultures are also employed to effect artificial ageing.

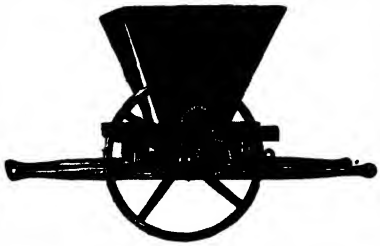
Up to now we have confined ourselves to the consideration of natural wines, but, in practice, other substances are employed in the course of manufacture. Thus, sugar is added before fermentation if less than 20 per cent. be present in the must. It is also necessary to reduce the amount of acid to 2 per cent. by dilution and addition of sugar.

Cheap and Unfermented Wines. Much cheap wine is made by covering the marc with a solution of sugar containing 18 grammes to every litre for every 1 per cent. of alcohol required, and 250 grammes of marc are taken for every litre. After fermentation, the liquor is drained from the marc, and treated as already described. Large quantities of fictitious wines are prepared from dry raisins imported into this country and into France.

Wines containing alcohol are subjected to a duty when imported into this country, but unfermented grape juice is free of duty. A case arose in May, 1906, where, by the addition of a substance to the must, fermentation was retarded for some days, permitting the importation of the must into this country, after which it was allowed to ferment, so that the wine obtained from it could be sold free of duty, the revenue being thereby defrauded. It is stated that nearly 800,000 gals. of unfermented grape juice are imported annually into Great Britain, a large proportion of which is fermented and made into wine without payment of duty. Should this practice grow, which is quite likely from its profitable nature, it will be necessary to devise some means of dealing with the question. Unfermented wines are, however, sold for temperance purposes and for sacramental use. They consist mostly of unfermented fruit juice, sweetened with saccharin, and preserved with salicylic or boric acids.

Composition and Analysis. The composition of the different classes of wines varies considerably. Many wines, such as port, are fortified by the addition of alcohol, for natural wines never contain more than from 6 per cent. to 12 per cent. Below we give results, from various sources, obtained from analyses of the commoner varieties of wines.

Analyses are made for the purpose of determining the purity and detecting adulterants. Sugar, as well as alcohol, is sometimes added to wines. The colouring matter must be examined to see if some artificial colouring matter has been added. Preservatives should be tested for and sulphuric acid estimated to see whether calcium sulphate has been added (*plastering*). For this purpose a number of determinations are made, including specific gravity, total extract, fixed and volatile acids, tartaric acid, and percentage of alcohol.

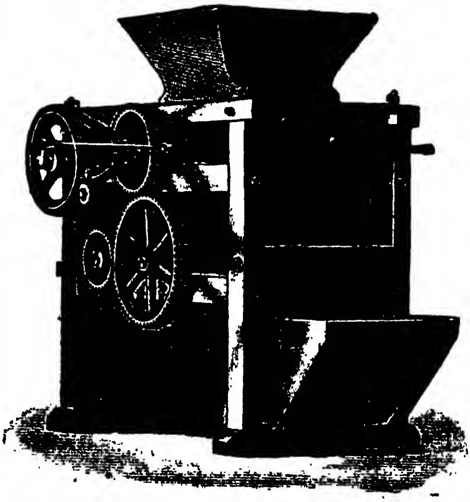


1. GRAPE MILL (Lumley & Co., Ltd.)

COMPOSITION OF WINES

Wines.	Alcohol, percentage by weight.	Extract.	Sugar.	Ash.	Phosphoric acid.	Fixed acid, as tartaric.	Volatile acid, as acetic	Tartaric acid.
Vin Ordinaire	7·0	5·0	0·1	0·45	—	0·61	0·11	—
Champagne ..	7·9	12·4	10·6	0·30	0·05	—	—	—
Hock	8·8	2·3	—	0·20	0·04	—	—	—
Sherry	17·2	4·2	2·5	0·40	0·02	0·27	0·15	0·18
Port	18·5	7·5	4·3	0·30	0·05	0·31	0·08	0·22

The determination of these figures does not present any special difficulty. The total extract is obtained by drying down a definite quantity of wine; volatile acid, by evaporating down once or twice with water and then titrating the residue; the difference between this and the total acid, also obtained by titration, gives the fixed acid. The percentage of alcohol is obtained by diluting 50 c.c. of wine with its own volume of water, and distilling. The distillate is made up to a known volume, and the alcohol it contains estimated by taking the gravity, as in the case of beer and spirits. Sugar is determined by means of Fehling's solution, while the polarimeter also yields useful information. There are generally fairly well defined relations between the proportions of these different constituents, and if the figures do not correspond, some adulteration may be suspected.



2. STEAM POWER CIDER MILL (Workman & Sons)

Fictitious wines are generally deficient in extract, although sometimes common salt is added to make up for this deficiency. The detection of added sugar is a very difficult matter, as it frequently consists of glucose, the most important natural sugar present in the wine.

Cider. British wines is a term applied to beverages made in the manner of wine from substances other than the juice of fresh grapes. The most important is cider, the best of which is made from astringent apples, special varieties being cultivated, which are suited only for this purpose. A good strong soil is required for growing the fruit, which should be regularly manured with phosphates, potassium salts, and charcoal dust [see MANURES]. When gathered, the apples are placed in heaps, preferably covered, to protect them from the rain, until they attain the right degree of maturity. The best cider is made from a judicious mixture of the different varieties; unsound fruit should be rejected.

Pulping and Pressing Apples. The older forms of mechanism for reducing apples to pulp were of a very primitive character. The apples were either mashed with a pestle in a trough or else placed in a cylinder provided with projecting spikes, in which revolved a drum, similarly fitted with spikes, and worked by a horse. In the more modern plan [2] the fruit is passed between wooden or stone rollers geared to different speeds. After mashing, the juice may be at once pressed out, as is generally the custom in this country, or the mashed pulp may be first allowed to undergo a certain amount of fermentation. When fermenting the juice itself the temperature should not rise above 40° F. The change proceeds rapidly, with much frothing; particles of fibrous material are carried to the surface by the bubbles of gas, but towards the end of the operation the solid particles settle to the bottom, leaving the liquid clear. It is immediately drawn off into fresh casks, where it undergoes a second fermentation. It is essential that the liquor, before fermentation, should be sufficiently rich in sugar, as, unless enough alcohol is formed in the first fermentation the secondary treatment does not proceed regularly, and acetic or lactic fermentation may set in, producing a flat-tasting, acid liquor. Sometimes fresh hops are added, as the tannin precipitates the albuminous matter. No doubt, a careful study of the most suitable yeast plant would result in great improvement in the development of the aroma and flavour, as in the case of wines. Good cider contains from 8 per cent. to 10 per cent. of alcohol and from 2 per cent. to 3 per cent. of sugar.

WINES AND CIDERS *concluded; followed by* MINERAL WATERS

BAND-SAWS & SAW BENCHES

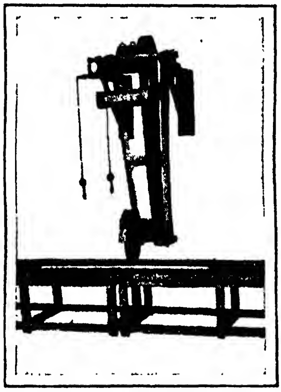
Band Re-saws. Cross-cut Saws. Portable Benches. Special Saws. Band-saws. Fret-saws

Continued from page 6146

By FRED HORNER

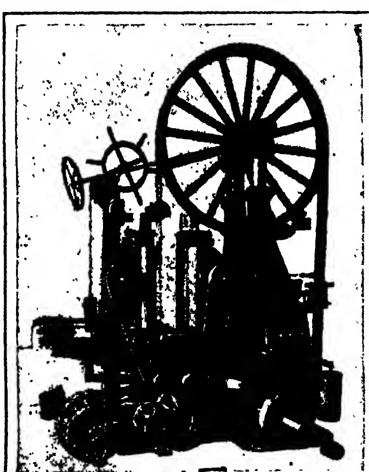
Band Re-saws. Band-saws for re-sawing are not quite so handy as the circular saws for general work, but they are popular in many cases on account of the thinness of the blade and the minimum of waste incurred in cutting. It is not a difficult matter to fit a self-acting feed to a band-saw table. In a few types a short rack-operated slide is placed on top of the table, to traverse the stuff, but the majority of machines use friction rollers, either one set, propelling the wood in contact with a fence, or a double set, both of which roll against the timber. An example of American practice is shown in 37, a Clement band re-saw (the American Wood Working Machinery Company), having 54-in. wheels, the lower one being out of sight in the photograph. The upper spindle is fitted in swivel bearings to align automatically. The pulleys are drawn apart and the saw kept in constant tension by a balance weight, which can be varied to suit the blade and the work it has to do. The feed works are driven at varying rates by belts and adjustable expansion cones, which admit of rates from 14 ft. to 120 ft. per minute. The movement is communicated to the rollers by spur gears and worm gears running in oil. Six feed rolls are used, three on each side of the saw; the right-hand ones are rigid in their bearings, but the left-hand set are elastic, to accommodate themselves to uneven stuff and so obtain a firm grip. The two sets may be used in a self-centring manner to split timber down the centre, or the right-hand set can be fixed rigidly to cut to one side. Roller guides are fitted above and below, to support the blade close to the wood, the upper guide being adjustable, to suit the differing thicknesses of stuff passed through. Two horizontal rollers support the bottom of the timber as it passes through the rolls. The greatest height of stuff which can be passed through is 30 in., and the width 20 in.

A fence and radial arm roller-feed is often put on band-saw tables, the action being then similar to that of the roller-feed circular-saw bench described on page 6145. On what are termed *combination machines* the fence and feeding arrangements are removable, to leave the table free for ordinary work, this type being useful in shops which cannot find sufficient work fully to occupy the automatic feed devices.



36. PENDULUM CROSS-CUT SAW

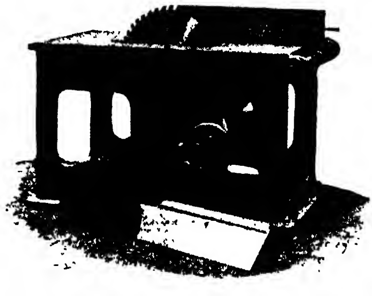
Cross-cut Saws. Before taking up the study of other classes of band and circular saws for kinds of work different from re-sawing proper, we have to note the *cross-cut* saws, which are employed for parting off deals, planks, boards, etc., to definite lengths. A good deal of this work is of a repetition character, especially for box-making and joinery, and means are provided for cutting numerous pieces to gauged lengths by the employment of fences or guides, or by putting two or more saws side by side to cut off the ends accurately. The *pendulum* saw [36] (John McDowall & Sons, Johnstone) is a pattern that is very commonly used, because of its cheapness, handiness, and the small space which it occupies. It comprises a rigid frame swinging in trunnion bearings on brackets attached to the roof or the wall, and carrying pulleys which are belted down to the saw spindle at the bottom; the saw can, therefore, be swung to and fro by pulling at a handle in the front, while a counterbalance, on levers at the upper part of the frame, draws the latter backwards automatically on letting go the handle, so keeping the saw out of the way until it is required. The spindle is started and stopped by shifting the belt on the fast and loose pulleys at the top shaft. The stuff to be parted is supported on the special bench seen in the illustration, a gap being cut through where the saw swings across. The bench may be constructed of any length required. For cutting pieces to uniform lengths there is provided an adjustable *stopper* that can be clamped in any longitudinal position, for the end of the timber to butt against, and so locate it accurately. To save lining off the lengths of timber previous to cutting various pieces, it is sometimes the practice to fit a metal rule with clamp stops, so that accurate subdivisions of the inch can be made by the sawyer. The largest saws used in these pendulum machines usually range up to 36 in., capable of working to 12 in. deep, but in a few instances saws up to 60 in. are employed for heavy work, including small logs. A guard is always fitted over the



37. A 54-IN. BAND RE-SAW

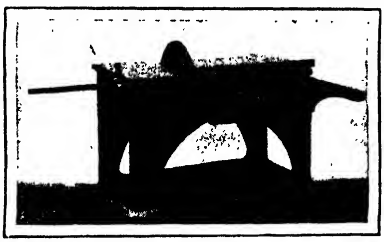
upper portion of the saw, as a protection against injury to the attendant.

Sliding Table Cross-cut Saw. The pendulum saw is especially handy for long or heavy pieces of wood, as they remain stationary. But when the length and weight of a piece permits, one of the several special cross-cut benches can be brought into use. The object is to traverse the timber across against the saw teeth, this being effected generally by a table running by rollers upon rails. Figure 39 shows one of Messrs. Robinson's benches of this pattern, which has the table of wood placed to the right of the circular saw and pulled to and fro by hand, as it runs with small V-wheels upon rails carried out to the front a sufficient distance. An adjustable gauge, fitted to a bar at the front left-hand side of the saw, provides for repetition sawing. The machine takes saws of 20 in. diameter, capable of cutting stuff up to 6 in. thick and 18 in. wide. The spindle is made to rise and fall in some of these machines. Double, or *equalising* saws, which trim off the two ends of a piece simultaneously, comprise a table travelling above a bed on which two headstocks are set in any desired position, to give variable widths. As the stuff is drawn over on the table the saws part it off at both ends simultaneously. Lengths from about 4 in. up to several feet are handled on these machines.



38. SAW BENCH, WITH RISING AND FALLING SPINDLE

Multiple Cross-cut Saws. *Multiple* saw machines are principally of two classes. In one a number of saws are set side by side to the required distance to part off a length of stuff into several pieces, such as paving blocks, the movement of the saws or of the wood carriage being continuous, so that at each stroke a piece of wood is completely cut up. Sometimes the saws are of differing diameters, gradually getting smaller, so that the work of sawing is gradual, and does not put so much strain on as though all the blades penetrated simultaneously. As many as 30,000 paving blocks can be sawn out in one day on these machines. In the other class of machine several saws are set in a long table, at differing distances apart, in order that stuff may be cut to various lengths, the pairs of saws being set in advance of each other, or, alternatively, sets may be caused to disappear below the table, leaving only those standing up which are required. The travelling tables are abolished in certain designs, and their functions performed by endless chains, having dogs which engage in the sides of the timber, and push it against the saws. These *lumber trimmers*, as they are termed in American practice, are built up with timber framings, forming a cheap and satisfactory construction. Pieces up to 20 ft. or more can be dealt with.



39. SLIDING TABLE CROSS-CUT SAW

The pendulum principle, already noted in connection with a suspended saw, is applied to benches, notably for cutting up paving blocks and similar work. The saw spindle runs in bearings at the end of a swinging arm, on the central pivot-shaft of which the driving pulley is mounted. The saw with its arm is pulled over by a hand or foot lever, or automatically by a crank-rod, to pass between the opening of an inclined fence, against which the timber is laid. The automatic crank-driven machines are, of course, the quickest in operation, and will cut the stuff as fast as a man can supply it.

One particular design of bench, which differs from those already described, is intended to deal with heavy planks and scantlings that are too heavy to be conveniently handled about and fed to a saw. The timber is laid upon a fixed table, and cut by a circular saw projecting up through a slot therein, the spindle running in bearings that can be fed longitudinally on a subsidiary bed. The foregoing machines for re-sawing and cutting off prepare the stuff for further treatment (when required) on other kinds of saws, which we shall now deal with.

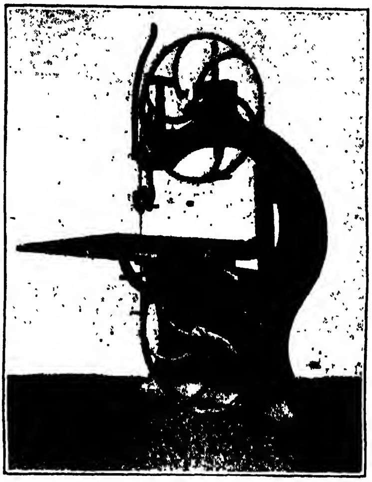
Plain Benches. The lighter types of circular and band saws, which are not fitted with mechanical feeds, appear in several forms, modified variously to suit the classes of work they have to do. The *plain* circular saw benches resemble those in **33**, **34**, and **35** [pages 6145 and 6146], but without the special attachments required for feeding, the only fitting being a fence, which is adjustable to and from the saw. The usual method of attaching the fence is by means of a circular steel bar at the end of the table, enabling lateral adjustments to be made, or, if necessary, the fence can be thrown back out of the way, leaving the table quite clear for cross-cutting. The fence proper has a *fence-plate* bolted to its front face, which can be moved to and fro as desired to suit saws of smaller or larger diameter. For bevel cutting, a canting movement has to be provided for the fence. The larger machines have rollers placed at each end of the table, similarly to **35** [page 6146], to assist in the easy handling of heavy pieces.

40. SAW BENCH, WITH RISING AND FALLING TABLE

Portable Benches. *Portable* saw benches, mounted on four trolley wheels, are used by shipbuilders and contractors, the machines being run to any locality where they are wanted, instead of transporting the timbers to the saw. An electric

motor drives the spindle direct, and the table is swivelled upon a turntable, to present the saw at any horizontal angle to the work, instead of shifting the latter. The limits of dimensions in these machines usually range up to about 4 ft. by 3 ft. 8 in. tables.

Wood Framings. A difference in the framing and the table is made in many benches, especially American, wood being employed instead of cast iron. The uprights and horizontals are mortised and bolted together, like a work bench, and the table is built of a number of narrow strips of different woods, glued together, and fastened to cross-girts, so that warping or splitting is impossible. Or the framing is made of cast iron, and the table only constructed with strips.



41. 30-IN. BAND-SAWING MACHINE

Rising and Falling Types. The range of the plain benches is rather limited, and other types are therefore used for an extended class of operations, especially in joinery work. In one type, with *rising and falling* spindle, the spindle may be moved upwards or downwards in relation to the table; in the other the movement is imparted to the table. The object in each case is to vary the depth of cut, so that the machines are adapted for grooving, tonguing, rebating, beading, and tenoning, by fitting special saws, or cutter blocks to the spindle. The saws are either *thick* for grooving, or *drunken* for grooving and tenoning. These tools will be described later, together with the cutter-heads employed. Figure **33** represents one of Messrs. Robinson's rising spindle benches. The bearings for the spindle are carried on a sliding bracket, which is vertically adjustable, by turning the hand wheel seen at the front. A boring apparatus is sometimes added to these machines, by fitting an auger in the end of the spindle, and attaching a sliding table to a bracket standing out from the side of the frame. The objection to altering the spindle height is that the belt-driving arrangements are complicated by the variations, and the rising and falling table machines are, therefore, preferred. The only disadvantage possessed by them is that the differing height of the table is sometimes apt to become awkward to the sawyer, but there is not much weight in this objection. There are two devices employed for operating the tables—racks and screws. The latter are better for the purpose, and are used in the majority of machines. The appearance of a rising table bench is shown in **40** (Robinson), the adjustment being effected by the hand wheel at the right-hand end, operating bevel gears connecting to two vertical square-threaded screws which cause the table to move by means of extensions in gibbed guide ways.

42 FRET-SAWING MACHINE

A groove is sometimes planed longitudinally in the tables to take a sliding fence, for use in cross-cutting, the fence lying at right angles to the main one; mitre cutting can be done by attaching a supplementary mitre fence. The lighter classes of rising-table machines are constructed with a narrow pillar or column, instead of the spread-out casting seen in previous illustrations.

Dimension Saws. The *dimension* or *two-spindle* saws are designed for both ripping and cross-cutting, and have two saws sharpened for cutting with and across the grain respectively. The spindles run in bearings at the opposite ends of a strong arm, pivoted about its centre in order that either of the saws may be brought up to the top ready for action, a hand wheel accomplishing this movement. The drive to the spindles is arranged so that the lower saw is thrown out of action. The special value of the dimension saws lies in repetition work, where large numbers of pieces have to be sawn to uniform sizes, as in cabinet work, pattern making, parquetry work, etc. Angular and bevel sawing is readily done by the aid of the canting and swivelling fence.

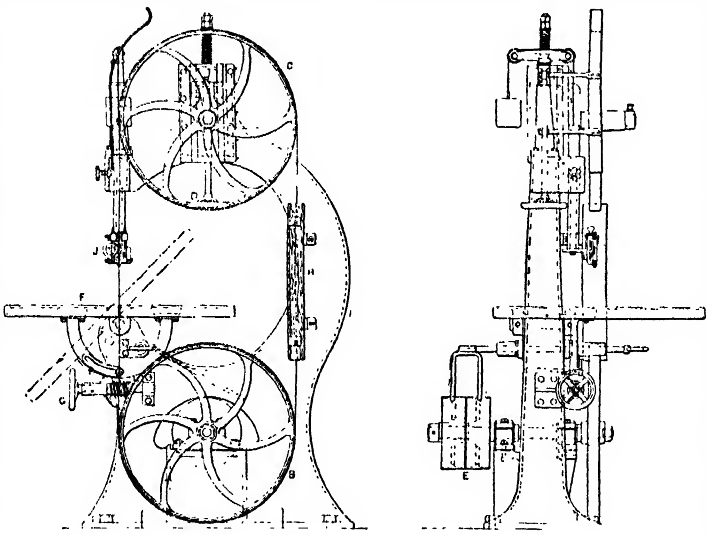
Universal Benches. *Universal* saw-benches embody the two-spindle arrangement, together with a tilting motion of the table, to present the stuff angularly in relation to the saw. Several auxiliary fittings, as gauges and angular fences, are provided, so that every class of sawing can be done, to build up intricate framings accurately.

Band-saws. The band-saw machines are particularly useful for general sawing which includes curved work, because they can tackle sweeps for which the circular saw is useless. The chief drawback is the trouble caused by breakages of saws, though this in many cases is avoidable if care is exercised.

Figure **41** gives a good idea of the general appearance of a typical machine, and **43** shows the same in side and front elevations, the example being from the practice of Messrs. Thomas White & Sons, Paisley. The saw pulleys are of 30 in. diameter and make 400 revolutions per minute. The framing A is of box section, cored out, which affords a very stiff form, able to resist the effects of vibration at the high speed necessary. The cast-iron pulleys B, C have no flanges, and are rubber tyred to avoid damage to the saw teeth, and the top wheel C is mounted on a spindle which runs in a hinged

bearing, that can be tilted to make the saw run on any part of the pulley. The hand wheel D operates a screw which slides the bearing of the wheel C up or down to suit the length of saw, and a constant tension is maintained afterwards by the coiled spring at the top. A balance weight and lever is fitted in some machines instead of a spring. The belt drives to the fast and loose pulleys at E, and is shifted across to start or stop the machine by the forks and hand lever passing through the frame. F is the table, constructed with an extension to cover over the pulley B and prevent pieces of wood from falling on it. The table is tilted or canted for angular sawing by turning the hand wheel G, which rotates a worm engaging in a worm segment on a quadrant bolted to the table, and turning the latter upon its pivot. The saw passes through a timber casing at H, and through a *guide* at J. The latter is an important feature, as it has to receive the backward thrust of the saw, and must do this without undue friction, or heating and crystallisation will occur, resulting in breakage of the saw. Rolling contact is the proper method, and there are several designs of guides in use. Jackson's, which is fitted to the machine illustrated, embodies a revolving disc, mounted on a spindle, and running by its back edge upon a ring of hardened steel balls. The back of the saw bears across a good portion of the face of the disc, and the latter runs with perfect freedom. The blade is confined sideways between two hardwood strips, adjustable for width of opening. The guide is brought down as close as possible to the stuff being sawn, and is, therefore, held in a vertical bar passing a socket in the frame A, in which it is clamped in any position by a hand screw. The bar is counterbalanced by a rope and weight to prevent it from dropping when the hand screw is loosened.

The saw passes through hardwood strips let into the table, and a rotary guide is also often fitted below the table, though in some instances nothing but wood guides are employed. The lower saw pulley is in many machines provided with a little brush, which is a considerable advantage, keeping the pulleys clear of sawdust, etc.



43. 30-IN. BAND-SAWING MACHINE

A special class of band-sawing machine, used chiefly by shipbuilders, coachbuilders, and others who have to cut out heavy ribs and bevelled pieces, is constructed with the top pulley to cant over bodily along with the upper part of the frame, so that the saw lies at an angle to the table. The latter remains horizontal, a fact which renders the handling of heavy pieces of timber much easier than as though they had to be moved about on a sloping table.

A fence is fitted to the tables of band-saws when wanted, to guide straight stuff past the saw, otherwise the operator must work to a scribed line on the timber, as in sawing curves. Combination machines, embodying both circular and band-saws, are designed chiefly for small works which either cannot afford or cannot spare space for two separate machines. The band-saw framing is built on the end of the saw bench. The smallest machines are hand-driven.

Fret or Jig or Scroll Saws. These have but a limited scope, and are used for internal cutting and scroll work which a band-saw could not manage, as the fret-saw blade can be disconnected and passed through a hole in the piece to cut out a central portion. The mechanism is simple, comprising a small crank-disc driven at a high speed, working a connecting rod which reciprocates the saw-blade, gripped in sliding holders above and below a table. The rate of working is about 1,000 strokes per minute. There are two types of machine; one has a curved cast-iron framing reaching round the table and up to the top holder, the framing, therefore, preventing very large work from being placed in position. In the other type, a suspended tension head of wood is used, consisting of a vertical beam attached to the ceiling, and strained tightly by three tie-rods, put in tension, by nuts on right and left-hand screws [see **42**]. The entire space around the table is free, and work of any area can be put on. In the machine illustrated, tension is given to the saw by means of a couple of spiral springs, which constantly maintain an even pull. A boring attachment is shown alongside the framing, to prepare work by making holes where they are necessary to insert the saw.

Continued

THE MANAGEMENT OF SHIPS

The Commercial Side of Shipping. The Shore Departments. Marine Officers and Seamen. Training, Promotion, and Salaries

continued from page 62_7

By W. CAMPBELL GALBRAITH

THE supremacy of British shipping is due principally to the efficient working of its commercial side. Nearly one out of every two merchant ships afloat is under the Red Ensign, and this because shipping in this country is a highly organised commercial business, free in its working from control of any Government department. Subjected as it is to free competition of home and foreign rivals, every improvement in steam navigation has been eagerly taken advantage of, and every economical device to save fuel or the expenses of working a ship is tried, and, if effective, adopted by the British shipowner.

Management. Each of the large shipping companies has its own method of management, which has been evolved by its directors and managers from their experience and knowledge of the particular requirements of the services their vessels perform.

In the case of a large limited liability company, such as the principal liners belong to, there are, of course, the directors elected by the shareholders, and a manager or secretary appointed by the directors. In the case of privately owned firms, there are one or more managing partners, who look after the business. The directors or partners decide the general policy and the particular trades on which their vessels run; they fix rates of freight and passage money, sometimes in conference with other shipowners, more frequently in rivalry with them, and in deciding these matters the directors have available their managers or other experts, who are usually the heads of departments.

As methods of management vary, so does organisation; but, generally speaking, in the larger companies, at any rate, it would be somewhat as follows. First would come the manager or secretary—in some cases there are both—who, subject to the directors, is in charge of the whole business, and under whom come the heads of the various departments, who report to the manager and take their orders from him. The various departments, generally speaking, would be as follow.

Accounts and Statistics Department. This department is usually under charge of an accountant well versed in shipping matters, and is one of the most important branches. All the bookkeeping is done here. Voyage accounts are compiled, profit and loss sheets made up, statistics of all sorts brought out, and generally everything pertaining to figures and working costs are furnished at call from this department.

The shipowner of to-day can quote an intending charterer with a rate for his steamer at once by referring to his accounts department, and if he proposes to send his steamer on a particular voyage outside the ordinary run, he calls for and is furnished with a pro forma voyage account, which puts before him the probable voyage expenses and earnings, and he quotes his rates accordingly. An account of this kind would be drawn out something as under.

PRO FORMA VOYAGE ACCOUNT

s.s. ——— - tons gross ——— nett

Voyage from —— to —— —— days speed — knots.

DISBURSEMENTS		EARNINGS	
Wages of crew — days @ £	= £	In this column would appear the estimated earnings worked out as so many tons at the rates to be quoted.	
Port and light dues ..	= £		
Victualling — days @	=		
Loading and discharging — tons @	=		
Coal — per day - total tons @ —			
Depreciation on £ @ per cent.	=		
Insurance on £ @ per cent.			
Deck stores	=		
Engine stores	=		
Repairs and sundries	=		
Commission account	=		
Total	£	Total	£

Estimated profit on the voyage £

Rate per ton per month — £

Of course, for steamers going through the Suez Canal the canal dues would appear as a big item on the disbursement side. The department has records showing the port dues, loading and discharging rates, and cost of coal at practically every commercial port. The depreciation and insurance are calculated on the book value of the steamer, and the average cost of many voyages gives the figures for deck and engine stores and repairs. In this department a practical knowledge of bookkeeping, of exchanges and figures generally, are necessary.

Marine and Engineering Department In small companies owning up to, say, half a dozen small steamers, or of one or two steamer companies, the masters and chief engineers of the vessels discuss with the owner the repairs, etc., required, and tenders for these are called for, and, as a rule, go to the cheapest offerer. Every big line, however, has a marine superintendent and a superintendent engineer (usually one of the most efficient and trusted commanders and chief engineers selected and taken ashore on the staff for the purpose), and they are responsible for all technical details connected with the deck and engine-room departments. In their hands, too, are left the selection and appointment of officers and engineers, as well as the promotion and transfer of the marine and engineering staffs. All questions of repairs, alterations, and so forth are dealt with in this department, and in the case of new vessels these officials give to the directors and managers the benefit of their technical advice.

These experts report on new inventions, and recommend their adoption or otherwise. When a new patent is adopted, close observation and record is made of its efficiency, and this department looks after all such records. The logs of the various steamers are entered up, their mileage and speed tabulated, their coal and oil consumption noted,

and in the case of excess over the usual average the captain and chief engineer are called on to explain the reason. In this way a check is kept on coal and oil expenditure, and careful and efficient marine and engineering superintendents mean much in the economical working of a big line. Besides the superintendents, the staff in this department is usually made up of one or more draughtsmen, an electrician, two or three junior clerks, and a few typewriters.

The young man entered in this department should apply himself to obtaining an accurate knowledge of the technical names of the different parts of a ship and her machinery.

Coal and Stores Department. On an estimate prepared for the year, this department will call for prices from contractors on their "suppliers list," and make contracts for the stores and coal required for the period fixed, usually six months to a year. In the stores department will be found samples of all the innumerable articles required by a modern ship, such as cordage, manilla and wire ropes, oils and paints, canvas, ironmongery, lamps, electroplate, cutlery, earthenware and glass, napery and linen, etc. These samples are carefully compared with the goods delivered by the various contractors, and any departure from sample is brought at once to the notice of the offending party.

When an "indent," as it is usually termed, meaning a requisition for stores sent in by the deck and engine departments, has been passed by the superintendent concerned, it is sent to the stores department. Here it is dissected, and orders sent for the stores indented to the various contractors.

A few junior clerks suffice for the work here, which is mostly routine, sending out orders and carefully checking suppliers' invoices with the ships' receipts and contracts. The responsible official in charge of this department is known generally as "the ship's husband," a happy description indeed.

Victualling Department. In close connection with the stores department is the victualling department. In some companies, in fact, they are one, and the stores do the victualling work as well. The shore purser or superintending steward is in charge here.

Into this department comes the indents from the chief stewards of the various steamers, giving their requirements for provisions, meat, wines, etc., for the next voyage. These requirements are based, of course, on the number of passengers to be carried and on the length of the voyage. Striking figures have been published of the huge piles of perishable stores, of the mountains of bread, fish, fowls, meat, hams, eggs, and so forth, consumed on a voyage of one of the Atlantic greyhounds, but such statistics scarcely come within the scope of this article.

Regular and careful accounts are kept, and on the averages a daily victualling scale is fixed to which chief stewards have to conform. The picking and selection of the chief stewards is in the hands of the shore chief, and a good and careful chief ashore is usually reflected in the work of the men afloat.

General and Correspondence Department. This department has usually at its head the general manager or secretary. In the case of firms owning a few steamers it is run directly, very often, by the partners themselves. The staff is usually the largest in a shipping office, as all the general routine work of an ordinary business office is dealt with here. Here, also, is the cash department presided over by the cashier.

Passengers are booked, passage tickets issued, and inquiries answered. Sailing and advertisement cards usually adorn the walls, and cabin plans of the company's steamers lie on the counters.

The young man entering a shipping office usually begins here, being drafted to other departments later for experience, or according to his aptitude. He starts, as a rule, by copying letters and documents and fetching and carrying for his seniors. A knowledge of shorthand should be possessed by every youth, and if he is able to use a typewriter so much the better. Typewriters, however, are usually engaged as such and kept to that work. There is a call also for a knowledge of languages, particularly French and German, and especially German, for the German is found running practically everywhere now, entailing correspondence regarding freights, passengers, and general interests.

Freight and Bills of Lading. This department looks after the engagement of freight, etc., and is usually divided into export and import sides. The export issues bills of lading for goods shipped from the home ports abroad, while the import department deals with the manifests and bills of lading for cargoes coming into the home ports.

In these days of keen competition the shipowner has to hustle to secure his freights. He does not wait for the shipper to come to him, but looks after the shipper. In London a representative of this department will be a member of the "Baltic." In Liverpool and Glasgow business is done on the "Exchange," and in Newcastle on the "Quayside," as the shipping exchange there is called locally. The "Baltic" in London is a palatial edifice in St. Mary Axe, replete with all comforts for its clients, and this may be termed the hub of the freight market in London. Here shippers and shipowners have full information as to freights and rates, and here they do their deals.

The freight department watches the trade journals, notes all big orders placed for railway materials for abroad, and then puts freights forward to the firms concerned. Here the early bird often catches the freight worm, and canvassers with a keen eye for business and an attractive manner are invaluable.

The freight being engaged, arrangements are made for shipment by a particular steamer. It is sent alongside by rail or barge, as is cheapest or most convenient, and is at the ship's risk from the time it leaves the quay wall or barge till clear of the ship's tackle when landed at the port of destination. As cargo comes on board, it is "tallied"—that is, a note is taken of the cargo, whether it is case, package, etc., and the "mark." A receipt is given, and this receipt, being presented to the freight department along with a bill of lading (which is usually in triplicate), is signed by the department "for the master," and it is then the merchant's title to the goods described. Only on production of this bill of lading, or an indemnity freeing the shipowner of all liability, will the goods be delivered to the consignee.

Particular trades, such as the Black Sea, Mediterranean, etc., have their own particular form of bill of lading, and most of the large companies have also a special form bearing their house flag or distinguishing emblem.

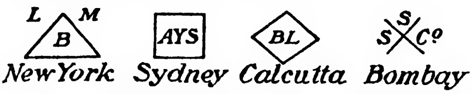
The Bill of Lading. The bill of lading gives the names of the shipper and the consignee, the name of the steamer and master, the port of shipment and the destination, the number of packages, and the date. On the margin is detailed the number of packages, their contents, and marks. Freight is payable on delivery of the

bill of lading "ship lost or not lost," and a recital is given of all the liabilities from which the shipowner frees himself, including "the act of God, the King's enemies, robbers by land and sea, restraint of princes, rulers, or people"; and such commonplace things as "strikes or stoppages of labour."

The shipowner has a lien on goods shipped for his freight. He is held responsible for loss or damage or short delivery, provided he has granted a "clean" bill of lading—this is a B/L without any remark as to the cargo being damaged or in bad condition.

All packages, as a rule, bear a mark, not an address, and all large shippers have their own particular mark, many of them well known in trade to the general public. Underneath the mark is the port of destination, and the package is usually numbered as well.

Sample marks are given below.



A mate's receipt granted on delivery to the ship and on which the bill of lading is made out would read something like this:

s.s.———

Date

Received in good order and condition on board the s s.———, ——— Master, the undernoted goods.

New York. ABC $ 1/3 3 *cases hardware.*

(sgd.) J. SMITH,
2/ mate.

A considerable number of clerks are employed in the freight department. Bills of lading for large ports have each, as a rule, a separate desk assigned to them, and the clerks employed check the bills of lading produced by the shipper with the mate's receipts, and make out the freight notes. This requires careful calculations. Goods are shipped on weight or measurement at the option of the steamer, and one freight note will involve many calculations of weight and measurement rates of freight.

The young man coming to this department needs all his wits about him. He must be careful and methodical, with a quick and accurate knowledge of figures. Here outside work is regarded as the "plum," and the ambition of the smart man is to get on the "Baltic," or shipping exchange, and do the outside freight work.

There is also usually an expert attached to this department skilled in estimating damage and settling losses. The outside public have little knowledge how many and various are the claims made by shippers for damaged or missing cargo. A smart, tactful man can save his employers thousands of pounds a year in the working of the "claims" department.

Insurance Department. In all large shipping companies there is an insurance department. It is usually in charge of an experienced man well versed in marine insurance law and customs. Many of the large shipping companies insure their steamers in a special fund of their own, and find it pays them to do so. The premiums, ranging as a rule from 4 per cent. to 6 per cent., are charged against each steamer's earnings, and credited to the "insurance fund." Against the insurance fund all claims for damage and losses are debited. The larger companies insure the cargo carried by their own steamers, and the baggage of passengers. In the case of companies where the insurance is done "outside," the risks are taken by Lloyd's and the other great maritime insurance companies.

The biggest outside policy for marine risks was the ten millions placed by the Government to cover the risks to merchant shipping during the summer manœuvres last year (1906).

Lloyd's. In marine insurance matters Lloyd's overshadows every other concern. It is also the great organisation for the collection and distribution of marine intelligence. All round our coasts and in every part of the world Lloyd's agents advise the movements of the ships of all nations, and not one vessel in ten bound to ports in the United Kingdom arrives as her terminal port without being "reported at Lloyd's."

Lloyd's, too, has a "Captains' Register," showing the service of every master in the mercantile marine, and in this connection much valuable and confidential information of great value to underwriters is available for the benefit and guidance of members and subscribers.

An inquiry office is also maintained by Lloyd's where relatives of the crew or passengers may obtain without cost information regarding the movements of the vessel in which they are interested.

It is scarcely within the province of this article, and space forbids any particular description of the business of Lloyd's, or the clauses which make up its marine policies, but to anyone engaged in shipping a knowledge of the abbreviations used is not only useful but necessary. Hereunder is a table of common abbreviations.

H.C.	Held covered.
S.A.	Subject to approval.
N.R.	No risk.
U.K. or C. ..	United Kingdom or Continent.
Cont. H. and H.	Continent between Harve and Hamburg.
Cont. B. and H.	Continent between Bordeaux and Hamburg.
F.O.	For orders.
O.P.	Open policy.
F.C. and S. ..	Free of capture and seizure.
D.C.	Deviation Clause.
T.L.O.	Total loss only.
F.A.A. ..	Free of all average.
F.G.A. ..	Foreign general average.
Y.A.R.	York Antwerp rules.
R.I.	Reinsurance.
R.D.C.	Running down Clause.
C.C.	Continuation Clause.
D.C.	Detention Clause.
L.C.	Label Clause (Bottled goods).
F.P.A.	Free of particular average.
P.A.	Particular average.
G.A.	General average.
P.L.	Partial loss.
S.L.	Salvage loss.
C.T.L.	Constructive total loss.
T.L.	Total loss.
W.P.	Without prejudice.
Wd.	Warranted.
W.A.	With average.
P.P.I.	Policy proof of interest.
A.R.	Against all risks.
W.O.B. ..	Washing overboard.

Lloyd's has a close connection indeed with the commercial side of shipping, and from the "A1 at Lloyd's," which describes the highest class granted to a merchant ship when she starts her first voyage, till her disappearance through loss or breaking up Lloyd's never loses sight of her.

In Lloyd's Register appears the name of every steamer and sailing ship afloat, showing the owner's name, the name of the builder, the classification, tonnage, and her general measurements, as well as her official number and port of registry.

The Merchant Shipping Act. This Act defines the duties and responsibilities of owners, masters, and crews, as well as the machinery of the

Board of Trade Mercantile Marine Offices (known to Merchant Jack as "the Shipping Office") and others authorised to deal with ships and seamen. The Act of 1894 in its 744 sections provides for practically every point likely to arise in connection with the owning or management of British vessels.

The first section of the Act gives the qualifications necessary for owning British ships, wherein it is laid down that a ship shall not be deemed to be a British ship unless owned wholly by persons of the following description—namely:

(*a*) Natural born British subjects.

(*b*) Persons naturalised by or in pursuance of an Act of Parliament or ordinance in a British possession.

(*c*) Persons made denizens by letter of denisation, and

(*d*) Bodies corporate established under and subject to the laws of some part of the King's dominions, and having their principal place of business in those dominions.

It is under the last qualification, of course, that the great majority of British shipping is registered.

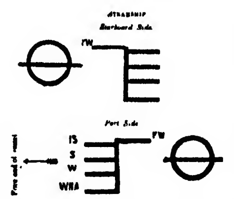
The second section of the Act provides for the registry of every British ship, and accordingly the first proceeding of an owner of a British vessel is to register her, and the procedure as to this is laid down in Sections 4 to 20 of the Act.

Registering a Ship. When a new steamer is built she is measured for tonnage by a Board of Trade surveyor, and the measurements so ascertained are embodied by the shipbuilder in a document known as "The Builder's Certificate," which is handed to the owner, who, on the figures given therein, makes out his "declaration of ownership." This document gives the name of the owners, their principal place of business, and the number of shares in the vessel. A vessel is divided into 64 shares, so that a sole owner would be described as owning 64/64th shares. This document, then duly signed before a shipping master or a commissioner of oaths, is handed in along with the builder's certificate and the certificate of the master, to the registrar of shipping at the port where the vessel is to be registered. The registrar then allots the vessel her "official number." This number having been carved on the main beam of the vessel, and her port of registry painted on the stern, and a carving note signed by a surveyor to that effect being furnished, the registrar grants the "certificate of registry." This is the vessel's most important document. It is at once her birth certificate and passport; without it she cannot obtain clearance from any port, and failure to produce it would render a vessel liable to seizure as an ownerless and suspicious craft. The certificate of registry shows the vessel's name, official number, and port of registry, gives full details of her measurement and tonnage, and the name of her owners and her master.

Selling a Ship. In the purchase or sale of a British ship there is little formality, no need for a lawyer, and the process is simplicity itself, a steamer valued at a million pounds being more easily disposed of than land or a house worth a hundred. The seller signs and seals a document known as *a bill of sale*, which gives the name of the steamer sold, and other particulars from her certificate of registry, the names of the sellers and buyers, and this document being handed over to the registrar of shipping at the steamer's port of registry, the old register is closed, and a certificate granted to the new purchaser, and the business is done. The bill of sale in its wording is a quaint survival of the days when the merchant ship was armed, as in its wording it transfers the shares "in the ship above particularly described, and in her boats, guns, ammunition, small arms, and appurtenances." The modern vessel, however, as a rule, has neither guns, ammunition, nor small arms, but the form survives. If a British vessel is lost, taken by the enemy, or sold to foreigners, notice of the fact must be given, under penalty, to the registrar, who thereupon closes the vessel's register. The owner is bound to give up the ship's certificate of registry if the steamer is sold to foreigners, or if it is saved in the event of wreck.

Legal Rights of the Crew. The Act provides and lays down conditions for the engagement of a crew, and every member of the crew must have the agreement read and explained to him by the shipping master or his deputy. Facilities are granted to seamen to complain of any grievance, and pains and penalties are enacted to protect the seamen from imposition of any kind. Even his food is provided to scale laid down in his agreement, and his quarters are certified to accommodate the number of crew.

The framers of the Act evidently looked on the sailor-man as a fool or a simpleton, and provision is made for him accordingly. "Jack," however, nowadays, at least, is quite competent to look after himself, and demand what he terms his "rights." In the agreement with the crew the freeboard of the steamer is given. This is a change from the bad old days of the "coffin ships," and the fixing of a safe freeboard was one of the points so strenuously fought for by the "seaman's friend," the late Samuel Plimsoll, M.P. The load-line cut and painted on the side of every British ship is known universally as the "Plimsoll Mark," and is shown below.



The letters shown on the load-line mark are FW, fresh water; the load draft of the vessel in fresh water, IS, Indian summer; S, summer; W, winter; and WNA, winter North Atlantic.

Part II. of the Act deals with masters and seamen, and makes provision for apprentices being carried. It also provides for the examination and grant of certificates to competent men, and states the conditions for the issue of licences to supply seamen, and for their engagement. The rating of AB—that is to say, able-bodied seaman—is granted only when the seaman has served at sea for four years.

Elaborate instructions are laid down regarding the discharge of seamen, payment of wages, seamen's money order and savings banks, and the property of deceased seamen. By law, everyone on a ship's articles is a "seaman," and when a seaman dies on board a British ship his wages and effects must be handed over by the master of the ship to the Board of Trade, who transmit these through a shipping office to the relatives of the deceased. Provision is made as to discipline, and for an official log, wherein is entered the record of any offences, births, deaths, etc. To be logged, to a seaman means much the same as a police conviction to a landsman.

The records of the service of all persons who serve in ships is kept at the office of the Registrar-General of Shipping and Seamen. The appointments of the Registrar-General and his staff are made by the Board of Trade, which, with the consent of the Treasury, regulates their salary and allowances. In this office are collected all the statistics as to

seamen, etc., also records of deaths, births, and marriages on board any British ship.

Provisions for Passengers. Part III. of the Act deals with passenger and emigrant ships, and regulates not only the equipment of such vessels, but fixes the number of passengers or emigrants such ships may carry. As to emigrants, the Act fixes that as regards steerage passengers no ship may carry more than :

(*a*) If the ship is a sailing ship, one adult to 33 tons of the ship's registered tonnage : and

(*b*) If the ship is a steamship, one adult to every 20 tons of the ship's registered tonnage.

Provision is made for the survey of passenger steamers, for the general equipment, for the maintenance of order, for the supply and inspection of provisions, water, and medical stores, and so forth.

Sundry Regulations. Part IV. of the Act deals with fishing-boats, and relates to "all fishing-boats and to the whole fishing service."

Part V. is headed "Safety," and deals with regulations for the prevention of collisions at sea, regulates the lights to be carried and exhibited, the fog signals to be used, and the steering and sailing rules to be observed. It also deals with the load-line, the loading of timber, and carriage of grain, and unseaworthy ships.

Part VI. sets up the machinery for special shipping inquiries and courts : and

Part VII. deals with delivery of goods and lien for freight.

Part VIII. defines the liabilities of shipowners, which the Act declares to be

(1) In respect of loss of life or personal injury, either alone or together, with loss of, or damage to, vessels, goods, merchandise, or other things, an aggregate amount not exceeding £15 for each ton of the ship's register ; and

(2) In respect of loss of, or damage to, vessels, goods, merchandise, or other things, whether there be in addition loss of life or personal injury or not, an aggregate amount not exceeding £8 for each ton of the ship's tonnage.

Part IX. deals with wreck and salvage, the registration of marine store dealers, the appointments of receivers of wrecks, etc. : and

Part X. fixes pilotage, and applies to all ships, British and foreign.

Part XI. deals with lighthouses and the levying of light dues, which under present arrangements are all borne by the shipowner, and which he justly claims should, in the United Kingdom, as elsewhere, be borne by the State.

Part XII. refers to the Mercantile Marine Fund, which deals with all charges in respect to fees for survey of ships, fees paid at the various shipping offices, etc.

Part XIII. deals with the methods of legal procedure ; and

Part XIV. is supplemental, and defines the general control of the Board of Trade, the appointment of surveyors, and inspectors, and the power of Colonial legislatures in regard to shipping.

The Mercantile Marine as a Profession. The mercantile marine to-day offers an excellent career to the man who has steadiness and intelligence to recommend him, and, as a rule, no other recommendation is necessary, for there is always a vacancy in the larger companies for the young man duly qualified as junior officer or engineer. The sea as a profession should certainly be considered by parents who have difficulty in deciding "what to do with the boys."

There are three departments open to the youth who decides to follow the sea : (*a*) as a deck officer ; (*b*) as an engineer ; and (*c*) the saloon department, as purser or steward.

To qualify as a *deck officer*, the youth must serve an apprenticeship, and he may do this in several ways. He may be sent by his parents to the training ships Worcester or Conway, for the two years' school course there. This will cost parents about £60 a year, but the boy gets a splendid training in seamanship and navigation, as well as an excellent general education. These two years in the Worcester or Conway are allowed to count as one year's sea service, but to be qualified to sit for examination for a second mate's certificate the youth must now serve three years at sea ; this he can put in as an apprentice in a sailing ship or as cadet or midshipman in a steamer. There is no difficulty in getting a youth apprenticed or appointed as a cadet. The large steamship companies, such as the British India Line, the New Zealand Shipping Company, Shaw Saville & Albion Co., Bucknall Bros., the Gulf Line, now carry cadets or apprentices, the premium ranging from 30 to 100 guineas, which is returned to the boys as wages. These companies endeavour to give the cadets a knowledge of seamanship, navigation, and the general duties of a navigating officer, but the steamer-trained officer is seldom up to the standard of the youth trained in a sailing ship.

A young man may also qualify by serving before the mast, as boy and O.S. (ordinary seaman), and many excellent captains and officers have begun their sea profession in the forecastle.

Nautical Examinations. After completion of the four years sea time the youth goes up for the Board of Trade examination for a second mate's certificate, and this obtained, he is fully qualified as a junior officer in the mercantile marine. The supply of officers is less than the demand, and the young man should experience no difficulty in obtaining a berth as fourth officer in one of the "liner" companies. His pay will run from £5 to £6 a month, with "all found"—that is to say, assuming a youth goes to sea between 15 and 16 years of age, by the time he is 20 he is in a position to keep himself. His first step is to third officer, when he is in charge of a watch : this step he should get in from a year to eighteen months in most large companies, and he now puts in his time for chief mate's certificate. This obtained, he is eligible for promotion to second officer, which rank he should reach after three to five years' service. Then he passes for master, and obtains afterwards, if he can, an extra master's certificate as the result of a further and special examination. Promotion to chief officer reaches him after seven to ten years, depending on the company he serves, and he reaches command after fifteen to twenty years' service. His pay as chief officer will run from £12 to £18 a month, and as commander from £20 to £60 a month, and in some exceptional lines and services he may get £800 to £1,000 a year.

Promotion. Promotion to command goes by seniority, tempered by selection, and the smart and efficient chief officer, as a rule, gets his command before men senior to him, who have not shown themselves so zealous for their employers' interests.

The large shipping companies, as a rule, engage only young officers, and train them themselves. These juniors receive promotion to the higher grades as vacancies occur, and only in exceptional cases is an officer or commander brought in over the heads of men in the service.

Application should be made in writing to the manager or marine superintendent of the line

selected, and the letter should be accompanied by copies of testimonials. This, as a rule, brings a reply, asking the applicant to call for a personal interview, and the interview being satisfactory, and his papers in order, an appointment follows.

Marine Engineers. To qualify for a marine engineer, an apprenticeship of at least five years must be served in an engineer's establishment—a marine engineer's shop for preference. Here the youth should begin at the age of 15 or 16, so that he will finish his time when he is between 20 and 21 years of age. During his apprenticeship the youth who desires to get on will attend evening technical classes in drawing, machine construction, and kindred subjects, all of which he will find most helpful when he goes up for his Board of Trade examinations, and throughout his career. The great marine shops are on the Clyde, in Scotland, and on the Tyne and the East Coast of England, and Belfast in Ireland. As a rule, no premium is charged, and in fact the majority of engineers regard the premium apprentice with suspicion, considering he is likely to have too much false dignity to learn his business properly. Wages are generally paid the apprentice, say 4s. a week the first year, rising by 1s. or 2s. a week each year of the five he serves. His apprenticeship completed, the young man should send in his application to the superintending engineer of three or four of the big companies. He should state clearly where he served his time, what special certificate he holds, his age, and send a copy of his apprenticeship certificate. When appointed, it may be as tenth engineer, or even as fifth or fourth, depending on the size and power of the steamer to which he is posted. His ambition is now to get his time in as a watch-keeping engineer, to enable him to obtain his second and chief engineer's certificate. Usually the second's examination is passed after about eighteen months to two years' sea service, and a chief's certificate is obtained after four to five years' sea service. Promotion depends on the line in which the engineer serves. He should be third after three to four years, second after seven to eight years, and chief engineer after 15 years' service. The pay of a junior engineer begins at £7 to £8 a month, with "all found"; as third he will receive £10 to £12, as second £14 to £18, and as chief £20 to £40, depending on the number of years' service. The chief engineer earns a bonus on savings in coal and oil consumption.

Pursers and Stewards. Only the large passenger boats carry pursers, and their duties vary according to the line on which employed. In some of the companies he is a clerk pure and simple, doing the captain's correspondence, writing out manifests, passenger lists, etc.; while in other lines he combines these duties with the general oversight of the saloon department. Generally speaking, however, the duties of purser and steward are separate. The purser usually secures his appointment through the nomination of a director, and puts in a few months or a year or so in the office of the company before he is sent afloat. There is nothing particularly exacting in the duties of this office, and a young man of average intelligence can easily acquire a knowledge of them. Vacancies, as a rule, seldom occur in the big lines. Pay will run from £6 to £12 a month,

Pursers are carried by river and pleasure steamers during the summer months, and here the duties are more concerned with the collection and issue of passengers' tickets. There are many applicants, and the pay is small, from 10s. to 30s. a week.
The young man who desires to go to sea as a steward must begin at the very bottom of the ladder, and, as a rule, he learns his experience in a hard school. The river and pleasure steamers, or in the steerage department of an Atlantic liner, would give an opening, and experience gained, the efficient steward works his way upward to chief by his own efforts. The pay of assistant stewards is nominal, and they depend on tips from passengers to a great extent. A chief steward will be paid from £8 to £12 a month. A knowledge of catering for passengers is essential to the efficient steward, and second only to this is tact.

Royal Naval Reserve. The officer or engineer desirous of serving his country or ambitious of social advantages, joins the Royal Naval Reserve. The qualifications necessary, aside from the fact that the applicant for a commission must be a British subject, are as under:

For midshipmen: a two years' course in one of the mercantile marine training ships, or a year at sea on board a first-class British ship. For sub-lieutenant: service as first mate of a first-class British steamship of at least 1,500 tons, or a sailing ship of 1,000 tons, and the possession of a master's certificate. Second and third mates are eligible provided that they have served for not less than six years at sea, excluding their time as apprentice, and for lieutenant, service in command of a steamer of 1,500 tons or a sailing ship of 1,000 tons is necessary for not less than one year.

A senior engineer must hold a first-class engineer's certificate, and have not less than 10 years' sea service, including three years as chief of a steamer of not less than 500 nominal horse-power.

An engineer must hold a first-class certificate and have seven years' sea service, including one year's service as chief engineer of a steamer of 200 nominal horse-power, or as second of a steamer of 500 horse-power, and an assistant-engineer must hold a first or second-class certificate and have served at least one year in a steamer as a certificated engineer.

Qualifying Drills. It is necessary for the lieutenant, sub-lieutenant and midshipman, to put in qualifying drills at stated periods, and such officers may volunteer to go through a twelvemonths' course of training in H.M. fleet. This course completed satisfactorily, officers are granted certificates, and become entitled to the following annual allowances:

Lieutenants ..	£25 a year.
Sub-lieutenants	20 a year.
Midshipmen ..	10 a year.

Officers of the reserve when called out for training receive the same pay and allowances as officers of the corresponding rank in the Royal Navy, and while on service they are treated in the same manner in every respect.

Besides the experience, and the social polish which a training in the Navy undoubtedly gives, and considering that an officer can live on his pay while serving, the annual allowance granted certainly makes it worth while for a merchant service officer to serve in the Reserve.

The tonnage of the mercantile marine under the Red Ensign grows and increases with the years, and the shrewd brains which control it are as capable now as ever, and if only the youth of the country, gentle and simple, would do their share, and come forward as they did in the years gone by, as officers and seamen, there seems no reason why the preponderance of our lead in shipping matters should not be maintained.

Continued

DYEING MACHINERY

Hand Dyeing. The Introduction of Machinery into Dyeing Practice. Typical Machines in Dyeing

Continued from page 6199

By HERBERT ROBSON

MACHINERY driven by power came into use in dyeing practically with the artificial dyes, and the subsequent enormous expansion of the trade. When the dyer had to deal with small quantities of goods—a few bundles of yarn or a small piece or two of cloth—he was content to use vats sunk to the level of the dye-house floor, as in the old and still-used process of indigo dyeing, and with tubs and kettles, working the goods with his hand, or, if the heat would not allow this, with rakes or forks or with a long crutch-like stick known as a "jigger." The resemblance of a billiard-rest to this article has given us a familiar slang-word.

Hand Dyeing. These hand-dyeing appliances do not require illustration. In cases where small quantities are to be handled, or when special care is required, they are still used. Moreover, it frequently happens that metal must not come into contact with the dye-bath, and in this case the use of a wooden vessel is compulsory. The ordinary form this takes is simply a strong, oblong box, fitted with a steam pipe below a perforated false bottom. The steam may be either blown in direct, or a closed steam coil may be used.

In dyeing hanks or skeins in this simple dye-vat the hanks are strung in festoons on sticks. These are ordinarily straight, but in some cases—in using the sulphur dyes, for instance—they are bent so as to keep the yarn constantly under the surface of the bath. The hanks are dipped into the bath, raised and lowered in the liquor a few times, and then left in the bath with the ends of the stick resting on the edges of the vat. The next stickful is then introduced in the same way, and when all have been entered, leaving a space between each to prevent entanglement, the first is lifted by two men standing one at each side of the vat. One of them thrusts a stick through the hanks and when the other has grasped his end, they lift the hanks so that they are well turned on the stick and the part of the yarn that was resting on it is now in the bath. The others are treated in the same way, and the yarn is said to have had "one turn." The men go on to give "three turns," or more, according to their judgment or instructions.

Dye-house Machinery. In the hand dyeing of cloth the goods are simply entered and worked about in any of the already-mentioned ways. A simple wince or skeleton roller may be provided over the dye-beck, and the goods, stitched in an endless band, are put over the wince and under guide rollers in the bath. The wince is then revolved and the cloth run through the bath until it is evenly dyed to shade.

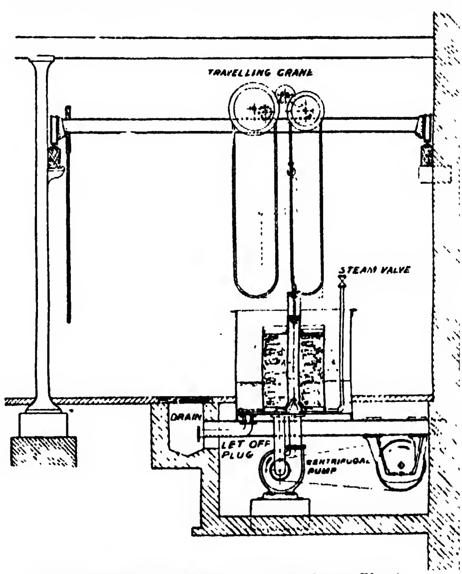
This dye-beck, with wince, represents the simplest form of dye-house machinery, and it is evident that it may be driven either by hand or power. The last thirty years or so has, however, seen the introduction of a great variety of machines for general use and for particular purposes.

Broadly speaking, the form of machine used differs little with the kind of fibre under treatment, but widely with the state of manufacture and the variety of material. In other words, a cop of yarn cannot be dyed like a piece of cloth nor will muslin stand the treatment of strong cloth or felt.

In this connection, however, silk must be looked upon as coming under the description of a "variety of material." The careful manipulation required makes it necessary to dye it by hand or with a simple form of machinery not liable to damage the fibre. The quantities ordinarily dealt with, moreover, allow most of the dyeing to be done by hand in wooden dye-vats or even in earthenware or porcelain vessels. It is dyed in the form of yarn or cloth; and in a few of the largest silk dye-houses some of the simpler form of machines used for dyeing cotton in the hank and in the piece have been adopted, in order to handle quantities rapidly.

In one form of special machine for silk yarn the hanks are placed over a reel, free at one end, so that they may be readily put on and taken off and run through a dye-vat, the reel or rollers revolving so as to pass every part of the hank continuously through the dye liquor. In another form, the hanks are hung on a pole, or between two poles, and carried through the dye-bath with a revolving action, to ensure even dyeing. As regards pieces, the wince arrangement already described is used, or a simple dye jig, which will be described later.

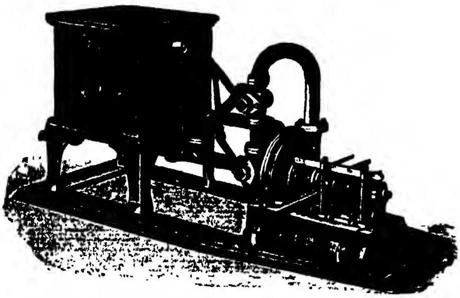
Wool and Cotton Dyeing. Wool and cotton are dyed in the raw or loose condition; in various states of preparation for the spinning frame, as rovings, sliver, or slubbing, for instance; as spun in cops; as hanks and warps; and in the form of woven fabrics. For each of these states a multiplicity of special machinery has been devised, and in this course it will be requisite to confine ourselves to typical machinery for each



7. OBERMAIER MACHINE (Mather & Platt)

form of material. It may be here stated, without fear of contradiction, that our British engineers are pre-eminent in this branch.

Loose Fibre. The advantage of using coloured weft cops, obviating the necessity of any

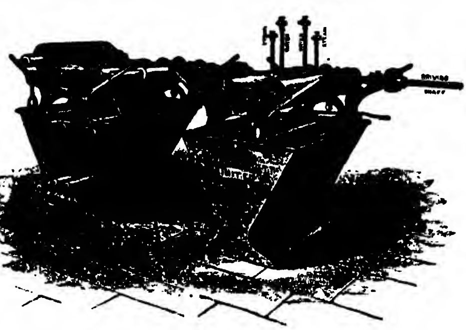


8. COP DYEING MACHINE (Walker & Rose)

subsequent reeling before introduction into the shuttles, is evident in the manufacture of fancy and parti-coloured fabrics. It is obvious that one way out of the difficulty of dyeing tightly wound cops through and through is to dye the wool or cotton before spinning. Technical difficulties, however, stand in the way, and the dyeing of loose fibre is not practised to a great extent. The dyed material injures the cards and soils the preparatory machinery generally. Wool, moreover, is liable to felt in the process, and cotton loses its "nature," as the spinners say, so that in either case the spinning is imperfect. In repeated attempts on a large scale to get over these difficulties, an acquaintance of the writer's lost a substantial fortune.

Still, in addition to the advantage of using coloured weft cops, there are other purposes for which raw cotton and wool are dyed. Different colours may be mixed and spun to produce required shades or fancy effects, or the loose fibre may be dyed to be used as coloured fillings. Moreover, another advantage, as concerns light shades, is that a faster colour is produced by mixing a dark coloured cotton with white, and then spinning, than by dyeing the cotton uniformly.

The Klauder-Weldon machine has been used for loose cotton, but it is unsuitable for wool. It is very similar to the modern washing machine in the steam laundry; a drum of copper netting containing

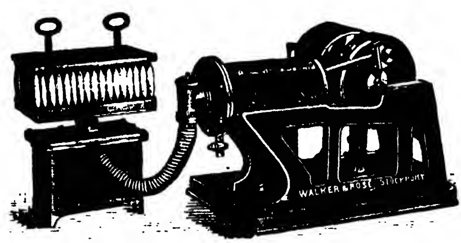


10. JIGGER DYEING MACHINE

the loose material revolves in a heated dye-bath until the dyeing is effected, and it is obvious that by changing the baths the same machine may be used for bleaching, mordanting, or washing. A much better machine for loose material is that of Obermaier, manufactured by Messrs. Mather & Platt. In this, the loose material is stationary, the liquor being forced through it, a point particularly important in the case of wool, as felting is avoided.

Sliver, or Slubbing. The advantages of the dyed cop are better obtained by dyeing what the spinner calls "preparation"—that is to say, the cotton in some state of preparation for the spindles. After it has been opened and scutched, a great amount of dirt has been removed, which interferes with the purity of shade when raw cotton is dyed, and if it has been carded, of course the injury caused to the cards by the mordant is obviated.

A fresh difficulty, however, arises. The slubbing, or sliver, must not be broken, and even cotton rovings would not stand the treatment which is allowable with raw cotton. The Obermaier machine [7], in which the material is left undisturbed, is the standard apparatus for the purpose, and this is illustrated in diagram. The movable copper cylinder can be lifted out of the dye-vat, as shown in the dotted lines, by means of the travelling crane. The vat is heated by steam, as shown. When the cylinder, which is varied in formation somewhat according to the material to be dyed, is packed with the goods, it is lowered into the vat, steam is turned on, and the centrifugal pump is set in action. This circulates the dye-liquor in the vat through the goods by means of the perforated centre tube, and back into the vat again. When the desired shade



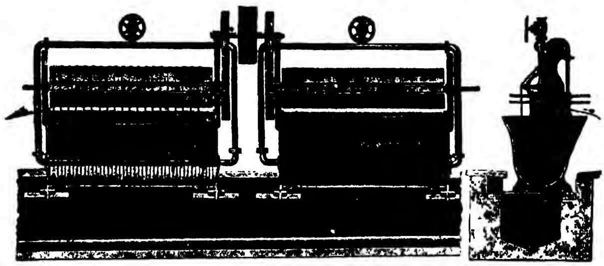
9. COP DYEING MACHINE (Walker & Rose)

is obtained, the cylinder is lifted, the goods are removed, and hydro extracted. They may be washed in the same receptacle, or dried in it by means of a current of hot air if desired.

Cop Dyeing. The cop is yarn as it is taken from the spindle. It is very compact, and consequently very difficult to dye. The advent of the direct cotton dyeing colours has, however, assisted the cop dyer, as they have great solubility, and do not require mordants, which, forming a solid lake on the fibre, interfere with the penetration of the inner layers of the cop. In dyeing, the cop is mounted on a hollow perforated spindle, and placed in a machine which forces the liquor completely through the yarn, or sucks it inwardly, or both. Weft cops for dyeing or bleaching are not mounted on the narrow paper tubes ordinarily employed in spinning weft (paper bottoms), but the first layers of yarn on the spindle are stiffened with a little paste (paste bottoms).

The cop dyeing machine of Walker & Rose, of Stockport [8 and 9], is shown herewith. The dye-vat is at one end of the machine, and the liquor is circulated by a centrifugal pump. Between the vat and the pump connecting piping is fixed, two taps being employed to allow the liquor to pass from the vat to the pump in either direction, as required. The advantage of an arrangement of this kind will be readily seen, as by reversing the liquor it can be

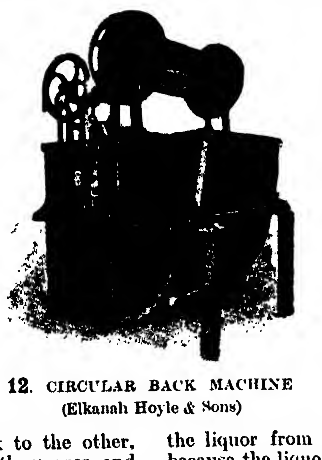
passed through the cops from the exterior to the interior, and vice versâ. The dye-vat can be made to receive any number of cops up to 1,200. The two stands to carry the cops are made portable, and are perforated to hold the hollow perforated skewers upon which the cops are mounted. At the base of the stands a chamber is formed, the bottom part being provided with a socket, so that when the perforated plates carrying the cops are in position, a water-tight joint is formed between the inlet pipe and the chamber, the liquor being thus confined and compelled to pass through the perforated plates and skewers, and consequently through the cops. The vat is heated by steam as usual. Ordinarily cop-dyeing machines are closed when in action, but this apparatus has the advantage of remaining open.



11. SPIRAL DYEING MACHINE (Mather & Platt)

Cheeses (small warps resembling a single Gloucester cheese) and spools (yarn wound, for instance, by means of a split drum) are dyed and bleached in the same form of machine, with slightly different mounting arrangements for the cheese or spool. As the yarn is less tightly wound, it is easier to get level shades throughout than in cop dyeing.

Hank or Skein Dyeing. The hank is the reeled yarn, and presents the form that is familiar to the public in skeins of thread. It requires very simple machinery; in fact, in dyeing yarn in hanks, the only thing to be avoided is the entanglement of the yarn. A typical form of yarn-dyeing machine is the Klauder-Weldon. In this, the yarns are arranged on a pair of rods suspended between a pair of revolving discs, which carry the yarn through the dye liquor contained in a semi-cylindrical vat. The hanks are steadily carried through the dye liquor, and there being no motion of the hanks, there is no chance of any entanglement. The machine works very successfully, is simple in operation, not liable to get out of order, is capable of dealing with large quantities of yarns, and is economical of dyestuffs.



12. CIRCULAR BACK MACHINE (Elkanah Hoyle & Sons)

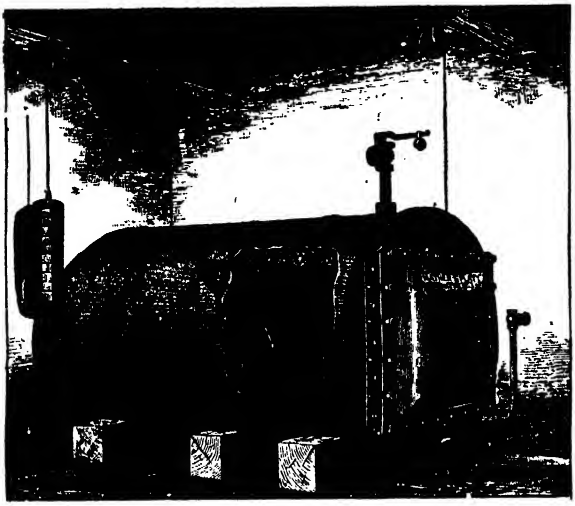
A very ingenious yarn-dyeing machine in that of Corron. In this, a rectangular dye tank is provided, and over it a travelling arrangement which, in passing from one end of the tank to the other, picks up the rods full of yarn, turns them over, and drops them back again.

A perfect hank-dyeing machine would seem to be one in which either the hanks are kept still and the liquor is caused to circulate through them, or one in which the hanks are carried through the dye liquor, but must not, while doing so, be subjected to any rapid movement tending to bring about entanglement of the hanks one with another. The hanks should not be tightly stretched, but hang somewhat loosely, because then the dye liquors can more thoroughly penetrate to every fibre of the hank.

Warp Dyeing. Warps are collections of yarns in long lengths ready for the loom. They come into the dyer's hands in several forms, but usually in large balls of about 12 in. in diameter (ball warps). In the process of dyeing the threads must not be entangled, otherwise they will not lie straight on the loom or pass freely through the eyes of the healds, and so breakages will occur that are undesirable.

The usual plan of warp dyeing is to have a vat with a number of guide rollers at the top and bottom, and to pass the warp round these rollers, and thus, as it passes through from the first to the last roller of the set, it travels several times through the liquor, and by running the warp backwards and forwards, giving it several "ends," it can be effectually dyed. This method works well; the threads of the warps can be kept level and straight, and the dyeing is uniform. It necessitates the unwinding of the ball of warp in the first instance on to a winding roller, and when dyed, rewinding back again into the ball form again, although if the dyer be also the manufacturer, this rewinding may be omitted, and the warp wound ready for use on the warp beam.

The problem comes up whether the warp could be dyed in the ball form, with all the threads in position and undisturbed. If it could be done efficiently and the colour be level throughout, then this method would save the trouble of unwinding and rewinding the warp. Now, simple immersion of the ball of warp into the dye liquor will not do, for it will not come up of a level shade. The dye liquors are found not to penetrate right into the centre of the ball of warp, and so the outside gets dyed the deepest shade while the centre either does not get dyed at all or only a pale tint. This want of penetration is caused by the tightness with which the ball is wound acting as a resist to the penetrative capacity of the liquor; and, secondly, there is no doubt that the air enclosed in the interstices of the warp in the interior of the ball prevents the liquor from getting into the central parts, because the liquor in turn prevents it getting away with sufficient freedom. What is wanted in order to dye a ball warp is some means of forcing the dye liquor right to the centre. Winding the warp into an Obermaier apparatus would do very well and perfect results can be obtained, but, as with the warp-dyeing machine, this necessitates unwinding and rewinding of the balls. Placing the warp into a closed chamber, and circulating the dye liquor through is an improvement, but even then there is much chance of the centre being paler than the

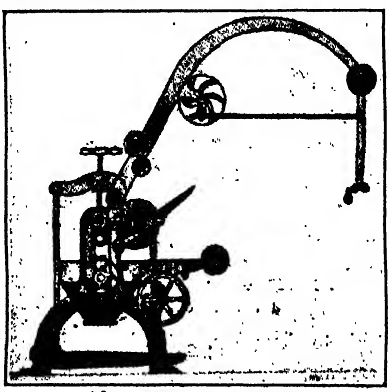


13. "COTTAGE" STEAMER (Mather & Platt)

outer portions. A better plan would be to wind the ball on a spindle in the first instance, and then to put the ball on a hollow perforated spindle through which the liquor can be forced. In this way a modified Obermaier can be used, and good results attained.

Jigger Dyeing Machine. The action of this simple "dye jig" is sufficiently explained in the illustration [10]. The cloth is wound on a roller, round the guide rollers shown at the bottom of the vat, and round a second roller. This is revolved, drawing the cloth through the bath and winding it. When all the cloth wound on it has had "one end" the action is reversed, and it is given as many ends as necessary. Then it is "batched" on to the large roller shown to the left of the figure. This "batching roller" is then removed for subsequent processes, washing, drying, etc. The reversal of the motion of the rollers is automatic, and there are simple arrangements for regulating the tension of the cloth. In dyeing calico and unions in the full width this is perhaps the most universally used machine.

The jigger is used for dark shades, as short strong baths can be used. When heavy drills or thick cloths generally are under treatment, the squeezing rollers are advisable as they drive the liquor into the goods. Only one batching roller is shown, but a similar roller can be mounted on any of the outstretched arms either to the right or left of the vat. For the purpose of attaching the cloth to the rollers it is a common practice to sew a piece of cloth tightly round each roller, leaving a loose end to which the piece can be attached.



14. PADDING MACHINE
(Elkanah Hoyle & Sons)

Spiral Dyeing Machine. In this machine [11] the cloth is not in tension and may be dyed in separate pieces between each peg or stitched together "on the endless system." The dye-beck is of cast iron and the section to the left shows the drain below, the "midfeather" acting as diaphragm, the perforated steam pipe passing into the beck, the peg rail at the top to keep the pieces from entangling, the wince, and the necessary steam fittings. The pieces, or the continuous band, traverse the beck in a spiral, as shown to the left of the figure, the loop at the bottom keeping the cloth fairly slack. This slack loop allows the cloth to remain longer in the liquor and promotes even dyeing. The machine is much used in dyeing on a large scale as the beck can be made of any practicable length, capable, say, of dealing with 30 pieces at a time.

Circular-back Machine. This [12] is a form of the dye-beck and wince for cloth already described. The illustration of the machine made by Elkanah Hoyle & Sons hardly needs description. It will be seen that this has a small cylinder engine attached, and the wince is driven by a reversible eccentric so that the cloth can be run through the bath either way as desired. This is principally used in Leeds and Huddersfield for West of England cloths.

Hawking Machine. This is used in dyeing when it is necessary to keep the cloth under the surface of the liquor throughout the operation to guard it from exposure to the air. It consists of a series of guide rollers arranged in the dye-vat so that they are completely covered with the liquor. The pieces are sewn together in an endless band and drawn continuously at full width through the bath by means of a pair of rollers, also, of course, under the surface of the liquor.

Padding. As the name implies, this is a rapid method of dyeing cloth suitable only for light shades. When one side of the cloth only is coloured this is called "slop-padding," a style of work very suitable for discharge effects. The ordinary padding machine consists of a trough containing guide rollers and with a pair of squeezing rollers above it. The cloth passes through the dye-liquor in the trough, round the guide rollers, between the squeezing rollers and away.

The machine illustrated [14], that of Elkanah Hoyle & Sons, has a pair of cast-iron rollers turned true and ground with emery so that the piece is nipped evenly from end to end including the selvedge. The rollers are wrapped with coarse padding cotton. The wooden trough underneath is for filling purposes, if filling should be required, and also can dye cotton with cold dye tinting, and is very useful should a piece be a little off shade. The machine is made to batch on arms from the top roller, which is of great assistance in keeping the piece well fixed on the roll, as well as for "cuttling down." This is an ordinary form of delivery from dyeing and finishing machines. It will be noted that the long arm delivering the cloth swings to and fro with the revolution of the wheel. This lays the cloth in long even folds on the floor below.

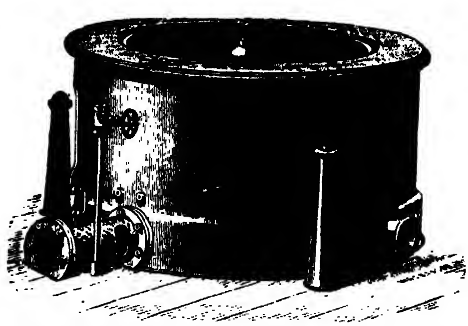
Steaming. After dyeing, some colours—for instance, aniline black, Turkey red, and many of the

alizarines—require steaming under pressure to develop and brighten the colour. The "Cottage" steamer [13] of Messrs. Mather & Platt is universally used. This is a strong wrought-iron cylinder, one end of which gives access by means of a sliding door with counterweights as shown. The section of the shell is removed merely for explanatory purposes. It is used either for yarn or cloth, and the position of the goods round the rollers can be varied from time to time by moving the exterior handle. Any pressure up to 30 lb. per square inch (roughly two atmospheres) may be used.

Soaping and Washing Machine. This continuous open width machine is shown in **15**. It can be made with any number of cisterns from one to twelve. In its most general application it is used as a combined raising or fixing, soaping and washing machine. Besides this use, it can also be employed with advantage for "cutting" indigo-dyed goods, developing naphthol colours, or chroming aniline blacks.

A medium-sized range, with six cisterns, can be used, utilised as follows: Starting from the right (1) raising or emetic cistern, (2) washing cistern, (3 and 4) two soaping cisterns, (5) clean soap cistern, (6) washing cistern with heavy squeezing bowls. The guide rollers are all of solid drawn metal, and the squeezing bowls of brass and rubber, or of brass and sycamore. With the exception of the raising cistern all the cisterns are fitted with beaters of non-corrodible metal placed below the surface of the liquor, and between the vertical laps of cloth. These beaters are driven independently at a high speed, whatever may be the speed of the cloth through the range, and they dash the liquor with great force upon both sides of the cloth, thus thoroughly cleansing it and loosening and removing any thickening matter which may have been used in the colours, and any by-products from the use of mordants or "cuts," while not the slightest injury is done even to the most delicate fabrics.

Wringing, Squeezing, and Hydro-extracting. The wringing-post has a hook or sort of short perch upon which yarn can be twisted by hand to drive off excess of moisture.

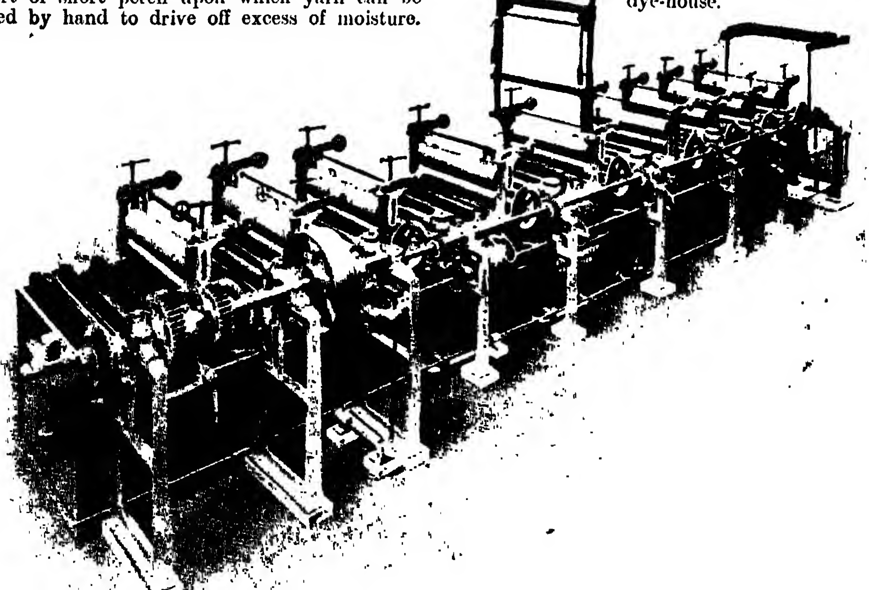


16. HYDRO-EXTRACTOR (Thos. Broadbent & Sons)

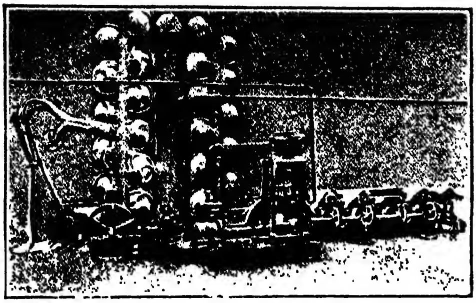
In squeezing, rollers are provided upon many machines, through which the yarn or cloth passes, and the excess liquor runs back into the bath. By taking advantage of the law of centrifugal force much more moisture can be driven off by means of a hydro-extractor. In wringing, less than 50 per cent. of moisture is removed; by squeezing, about 70 per cent.; whereas over 80 per cent. is driven off by "whizzing," as it is familiarly termed. The hydro-extractor is now largely used in the steam laundry, and the economy of this preliminary drying process will be apparent.

The hydro-extractor is a perforated metal basket, mounted in an outer case so that it can be revolved at a high rate of speed. The goods are packed into the inner basket and the machine is set in motion, revolving at the rate of 1,500 revolutions per minute. The water expressed by the powerful centrifugal force is thrown into the case, and escapes by means of a drain-pipe.

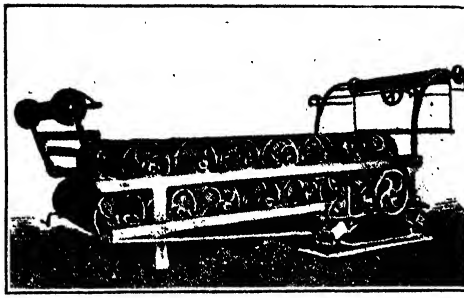
Hydro-extractors vary in detail according to the special use to which they are put. The type shown [16], manufactured by Thomas Broadbent & Sons, Ltd., is that ordinarily used in the dye-house.



15. SOAPING AND WASHING MACHINE (Mather & Platt)



17. DRYING CYLINDERS (Elkanah Hoyle & Sons)



18. DRYING CYLINDERS (Elkanah Hoyle & Sons)

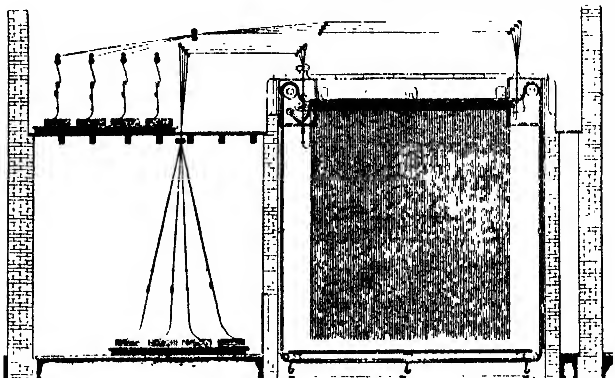
Washing. Thorough washing is one of the most important processes in the dye-house, and it is one that may have to be repeated several times in the stages through which the goods pass before they are ready for the market. All surplus mordant must be washed off before dyeing, otherwise it forms insoluble lakes in the dye-bath, wasting colour and leading to spotty dyeing. As a rule, but not always, the goods must be washed after dyeing to clear the fibre and to freshen the colour. As we have seen, the mordanting, dyeing, and washing may proceed as a continuous operation in a machine with several "holes," or the beck, or jigger, may be cleared of liquor and filled with clean water. Special machinery, however, is useful in some cases.

Drying Cylinders. The machine for drying both sides of the cloth takes the form of a number of cylinders heated by steam. These were all formerly, and are still, as a rule, made of tin-plates, and hence are commonly known to the finisher as "tins." "Drying over tins" is therefore the technical expression when the cloth is dried on both sides, while "drying over cylinders" is used when the cloth is dried on one side only.

The cylinders are heated by steam passing through their hollow axles, and revolve as the cloth passes over them, thus constantly bringing up a fresh heating surface. The machine shown in **18** is that of Elkanah Hoyle & Sons, and each cylinder is fitted with a patent water-bucket, which is emptied of the condensed steam every time the cylinder revolves.

The upright machine [**17**], also made by Messrs. Hoyle, is provided with a "five-holed squeezer," which is exactly similar to the crabbing machine already described, with the exception that there are five pairs of iron rollers and cast-iron troughs. This machine is largely used for all classes of ladies' dress goods, ladies' macintosh mantle cloths, and also for mohairs, and in it a continuous operation can be carried on of scouring, washing, setting, stiffening, and drying.

Steaming and Ageing. The continuous steaming and ageing machine [**19**] is referred to in all technical literature as the "Mather & Platt," a sufficient testimony to its universal application. It is a chamber fitted with a number of copper rollers to guide the piece while passing through. It is used for a large number of colours, which are developed by steaming, and for ageing aniline black, the steam acting as an oxidising agent. In the latest machines two or more "runs" of cloth can pass abreast. This enables a chamber of half the height or length of those constructed for a single run of pieces to turn out the same quantity of cloth. In the older machines it is necessary for the metal rods upon which the cloth hangs, after passing through the chamber, to be transported by hand or by special mechanism outside the chamber to the entering end again. This involves hand labour in every case, and also the exposure of the rods to a much lower temperature outside the chamber. To avoid the condensation which might form on their surfaces and produce stains on the cloth on re-entering the chamber, the rods are re-heated. In the new machine the rods are carried automatically within the chamber, from the point where the cloth leaves, back to the point where it enters the chamber. The machine requires no attention beyond seeing that the cloth enters straight into the chamber. A further improvement consists of an arrangement by which the rods revolve slowly, as they pass from one end of the chamber to the other, in such a manner that no portion of a piece of cloth remains in constant contact with the hot surface of the rods during the whole of the time it is passing through. In the steaming of some colours this is of great importance.



19. STEAMING AND AGEING MACHINE (Mather & Platt, Ltd.)

Continued

SOLUTION OF RIGHT-ANGLED TRIANGLES

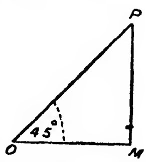
Ratios of 45°, 30°, 60°, 90°, 180°, 0°. Relations between the Ratios of an Angle and its Complement and Supplement. Compound Angles

continued from page 6282

By HERBERT J. ALLPORT, M.A.

18. The Trigonometrical Ratios of Certain Well-known Angles. The ratios of a few angles which are sub-multiples of two right angles can easily be found.

The Ratios of 45°. Let $\angle POM = 45°$. In one of the lines bounding the angle take any point P and draw PM $\perp$ to the other bounding line. Then, since the $\angle$s at O and M make up one and a half right angles, the remaining $\angle OPM$ must be half a right $\angle$. Hence, MP $= OM = m$, say. Therefore, if $OP = x$, we have $x^2 = m^2 + m^2$ (*Prop.* 34).



$$\therefore x = m\sqrt{2}.$$

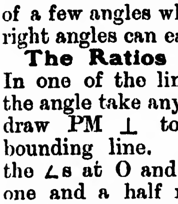
Hence,

$$\sin 45° = \frac{MP}{OP} = \frac{m}{m\sqrt{2}} = \frac{1}{\sqrt{2}}.$$

$$\cos 45° = \frac{OM}{OP} = \frac{m}{m\sqrt{2}} = \frac{1}{\sqrt{2}}.$$

$$\tan 45° = \frac{MP}{OM} = \frac{m}{m} = 1.$$

The Ratios of 60° and 30°. Let OPQ be an equilateral Δ. Then each of its $\angle$s is one-third of 180°, *i.e.*, 60°. Draw PM $\perp$ to OQ. Then



$$\Delta OMP = \Delta QMP \ (\textit{Prop. } 19).$$
$$\therefore \angle OPM = \angle QPM,$$

so that each of them is 30°. Also OM = QM, and OM is therefore half of OQ.

$\therefore$ if $OM = m$, we have $OP = 2m$,

and $MP^2 = OP^2 - OM^2$ (*Prop.* 34)

$= 4m^2 - m^2 = 3m^2$.

Hence, $MP = m\sqrt{3}$.

$$\therefore \sin 60° = \frac{MP}{OP} = \frac{m\sqrt{3}}{2m} = \frac{\sqrt{3}}{2}.$$

$$\cos 60° = \frac{OM}{OP} = \frac{m}{2m} = \frac{1}{2}.$$

$$\tan 60° = \frac{MP}{OM} = \frac{m\sqrt{3}}{m} = \sqrt{3}.$$

Also, since $\angle MPO = 30°$, we have

$$\sin 30° = \frac{OM}{OP} = \frac{m}{2m} = \frac{1}{2}.$$

$$\cos 30° = \frac{MP}{OP} = \frac{m\sqrt{3}}{2m} = \frac{\sqrt{3}}{2}.$$

$$\tan 30° = \frac{OM}{MP} = \frac{m}{m\sqrt{3}} = \frac{1}{\sqrt{3}}.$$

The Ratios of 0°, 90° and 180°. We have already seen, from Arts. 15, 16, 17, that

$\sin 0° = 0$, $\cos 0° = 1$, $\tan 0° = 0$.
$\sin 90° = 1$, $\cos 90° = 0$, $\tan 90° = \infty$.
$\sin 180° = 0$, $\cos 180° = -1$, $\tan 180° = 0$.

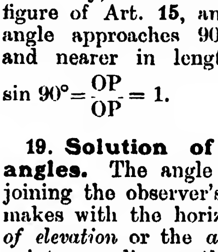
The values of the ratios thus found should be known by heart. Any required ratio is best remembered by thinking of the lengths of the sides of the triangles from which they are obtained. For example, if the value of cos 60° is required, think of the equilateral triangle, and it will easily be remembered that OM is half of OP, and therefore $\cos 60° = \frac{1}{2}$. In the same way, if sin 90° is required, think of the figure of Art. 15, and remember that as the angle approaches 90°, MP becomes nearer and nearer in length to OP, until finally

$$\sin 90° = \frac{OP}{OP} = 1.$$

19. Solution of Right-angled Triangles. The angle which the straight line joining the observer's eye to a distant point makes with the horizontal is called the *angle of elevation* or the *angle of depression* of the point, according as the point is *above* or *below* the observer.

The Trigonometrical Ratios are, in most cases, incommensurable numbers. Their approximate values have been found for all angles, differing by 1′, from 0° to 90°. It will be seen later that this is sufficient to determine the ratios of any angle whatever. [Chambers' Mathematical Tables. 3s. 6d.]

EXAMPLE 1. The angle of elevation of the top of a tower is 30°. From a point 250 feet nearer the foot of the tower the elevation is 60°. Find the height of the tower.



Let PM represent the tower, and let A, B be the points of observation, so that

$$AB = 250 \text{ feet}.$$

Let $PM = x$ feet, $BM = y$ feet.

Then $\frac{MP}{BM} = \tan 60°$,

and $\frac{MP}{AM} = \tan 30°$.

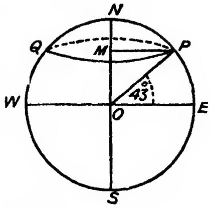
Hence, $\frac{x}{y} = \sqrt{3} \quad . \quad . \quad . \quad . \quad (1)$

and $\frac{x}{y + 250} = \frac{1}{\sqrt{3}} \quad . \quad . \quad . \quad . \quad (2)$

The solution of these two equations gives $x = 216{\cdot}5$ feet.

EXAMPLE 2. Find the distance travelled in an hour, in consequence of the earth's rotation, by a person situated in latitude 43°; given that

cos 43° = ·73135, and that the earth's radius = 4000 miles.



Let NS be the earth's axis, and P a point in latitude 43°, *i.e.*, ∠EOP = 43°. Draw PM ⊥ to ON. Then, owing to the earth's rotation, P describes a circle about M as centre. Also

$$\frac{MP}{OP} = \cos MPO = \cos EOP = \cos 43°$$

$\therefore$ MP = OP cos 43° = 4000 × ·73135 miles
= 2925·4 miles.

Hence, in one hour, the point P travels $\frac{1}{24}$ of the ○^{ce} of the ⊙ which P describes,

$$= \frac{1}{24} \times 2\pi \ . \ PM = \frac{2 \times 22 \times 2925 \cdot 4}{24 \times 7} \text{ miles}$$
766 miles.

20. Complement and Supplement of an Angle. We shall now prove that

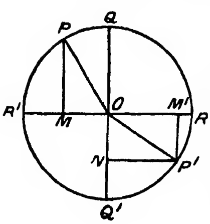
(i.) The sine of an angle = the cosine of its complement.

(ii.) The sine of an angle = the sine of its supplement.

(iii.) The cosine of an angle = – (the cosine of its supplement)

whatever the magnitude of the angle may be.

(i.) Let OP, starting from OR, trace out the angle A; and let OP′ trace out 90° – A, *i.e.*, let it first trace + 90° by turning in the positive direction up to OQ, and then turn back from OQ through the ∠QOP′, equal to – A.



Thus, in whatever quadrant OP lies, the ∠ROP which OP describes from OR is always equal to QOP′ which OP′ describes from OQ in the negative direction. Therefore P′N must always be equal to PM in magnitude, *i.e.*, OM′ = PM in magnitude. Also, by drawing figures in which OP lies in any other quadrant than the one shown, it will be seen that when P is *above* ROR′, P′ is to the *right* of QOQ′, and when P is *below* ROR′, P′ is to the left of QOQ′. Hence PM and OM′ always have the *same sign*.

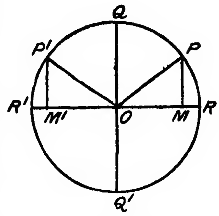
$\therefore$ for all values of the ∠A we have

$$\frac{MP}{OP} = \frac{OM'}{OP'},$$

i.e., sin A = cos (90° – A);

or, the sine of an angle = the cosine of its complement.

(ii.) As before, let one revolving line OP trace out the ∠A, and let the other, OP′, trace out 180° – A, by turning first into the position OR′ and then back through R′OP′, equal to – A.



Hence, since the angle which OP describes from OR is always equal to the angle which OP′ describes from OR′ in the opposite direction, we have M′P′ always equal to MP in magnitude. Also P and P′ must always be both on the same side of ROR′, so that MP and M′P′ have the same sign.

$$\therefore \frac{MP}{OP} \text{ is always equal to } \frac{M'P'}{OP'},$$

i.e., sin A = sin (180° – A).

(iii.) Again, OM and OM′ are clearly always equal in magnitude, and on whichever side of QOQ′ the point P lies, the point P′ will lie on the other. Hence, OM and OM′ are always of opposite sign.

$$\therefore \frac{OM}{OP} = -\frac{OM'}{OP'},$$

i.e., cos A = – cos (180° – A).

21. In the same way, the student can easily prove for himself such formulæ as

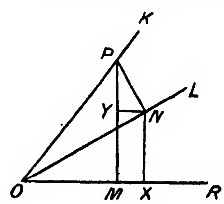
sin A = – cos (90° + A).
cos A = sin (90° + A).
sin A = – sin (180° + A).

22. Trigonometrical Ratios of Compound Angles. The "A, B" Formulæ. To prove that

sin (A + B) = sin A . cos B + cos A . sin B

and

cos (A + B) = cos A . cos B – sin A . sin B.



Let ROL be the angle A, and LOK the angle B. Then ROK is the angle (A + B). In OK, one of the arms of this angle, take any point P, and draw PM, PN ⊥ to OR, OL. Draw NX, NY ⊥ to OR, PM. Then, since ∠s PMO, PNO are right ∠s, ∴ a ⊙ on OP as diameter will pass through M and N (*Prop.* 39, *Cor.* 1). ∴ ∠s MPN, MON are in the same segment, and therefore are equal (*Prop.* 40). Hence ∠MPN = ∠A. Then,

$$\sin (A + B) = \frac{MP}{OP} = \frac{XN + YP}{OP} = \frac{XN}{OP} + \frac{YP}{OP}$$
$$= \frac{XN}{ON} \cdot \frac{ON}{OP} + \frac{YP}{PN} \cdot \frac{PN}{OP} \text{ (Art. 73, page 546)}$$
= sin ROL . cos LOK + cos MPN LOK
= sin A . cos B + cos A . sin B.

Again,

$$\cos (A + B) = \frac{OM}{OP} = \frac{OX - YN}{OP} = \frac{OX}{OP} - \frac{YN}{OP}$$
$$\frac{OX}{ON} \cdot \frac{ON}{OP} - \frac{YN}{PN} \cdot \frac{PN}{OP}$$
cos ROL . cos LOK – sin MPN . sin LOK
cos A . cos B – sin A . sin B.

Continued

MAKING FELT HATS

The Process of Manufacture. "Planking" and "Proofing." How the Shape is Blocked. Pressing and Finishing

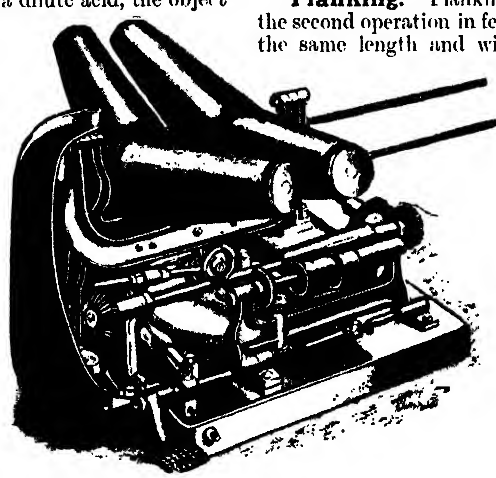
MEN'S HATS continued from page 6042

HUNDREDS of machines have been invented for the manufacture of felt hats, the end in view being to obtain the best machine possible for converting the wool into a good felt hat by the aid of heat, moisture, and friction.

As nearly the whole process of their manufacture is by machinery, we shall here consider the materials used, quantities required, the machinery employed, and so on.

Cleansing the Wool. Felt hats are made from the fur of the rabbit, beaver, nutria, etc., also from the wool of sheep and other animals. After obtaining the wool, it is necessary to give it a thorough washing to free it from the natural yolk or animal grease, or any foreign substance the wool contains, before the felting operation can be begun. It is afterwards passed through a "willow" for the purpose of opening it out.

The carbonising process may be done in a variety of ways by using a dilute acid, the object in view being to destroy all the vegetable matter which clings to the wool, for the presence of any such matter has a tendency to disfigure the appearance of the hats when finished. The wool is then passed through a carding engine, with its several rollers, wire combs and cylinders, which opens it out to an almost cobweb-like texture. It is next taken to the forming card, in front of which is placed the "forming machine" [10], and, as the wool is stripped by the comb from the doffer, it is taken up by the forming cone, which revolves upon four rolling cones. This machine has an oscillating motion from left to right, and vice versâ.

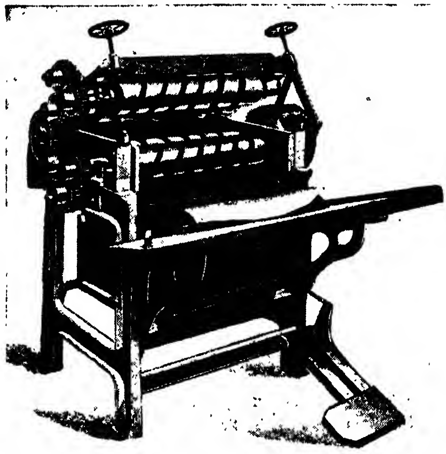


10. THE "FORMING" MACHINE

The "Forming" Process. By this means the wool coming from the doffer is crossed as it is received upon the double cone. This crossing of the wool upon the cone greatly facilitates the felting process. The reader will understand why this is if he refer to the articles on fibres on page 1995 of this work, and notice the structure of the wool fibre, the serrated ends, and the scales overlapping each other, which become interlocked in the operation of felting. When sufficient wool has been delivered upon the double cone, it is cut in two by the insertion of a pair of light shears in a recess which runs round the larger diameter. The forming is conducted by women, whose sensitiveness of touch enables them to determine when a sufficient weight of wool has been delivered on the cone [13]. After leaving the forming department, they are passed on to the hardener. There are two different methods of doing this, called "cup and cone" and "flat" hardening. The "cup and cone" hardener is a machine possessing a slow rotary movement. The wool "forms" are placed on a perforated copper cone, heated by steam: between each form is placed a cone-shaped cloth, to prevent the forms adhering to each other; the cup is then placed upon the cone, and its quick reciprocating movement gives the first operation of felting. The "flat" hardener performs precisely the same function as the "cup and cone" hardener; but in this case the felting is performed by friction between two plates [12].

"Planking." Planking—the next process—is the second operation in felting; the "forms" are the same length and width as when they left the former—14 in. by 21 in., but the soft wool-like appearance they possess has been changed to a cloth-like texture by the first felting process—that of hardening. In the planking department, "batteries" are arranged to accommodate from four to six men, the planks being about 30 in. by 40 in., in the centre of which is a large kettle filled with water, and heated by steam or fire to boiling point. Then the planker takes three or four of the forms, rolls them in a cloth, dips them in the boiling water, and rolls them on the plank to assist the shrinking operation; afterwards taking them from the cloth, to change their position before again repeating the same operation, to keep them in shape and prevent adhesion to each other. They are then taken to the "settler," who rolls the forms in a cloth and places them between the four rollers of the "settling" machine, the rings of which run in a transverse direction, the rings on the front rollers running from right to left, those on the back ones vice versâ [11].

The hat "forms" are felted up by this machine 4 in. or more if required. They are then placed in the "bumpers," which machine contains a



11. THE "SETTLING" MACHINE

pair of large blocks of oak, in the pit of which you place the hat "forms," or "hoods," where they are pounded and milled up to the required size. The finishing touches in this department, so far as machinery is concerned, are given on the "stumping" machine, which is somewhat like the "settling" machine in construction.

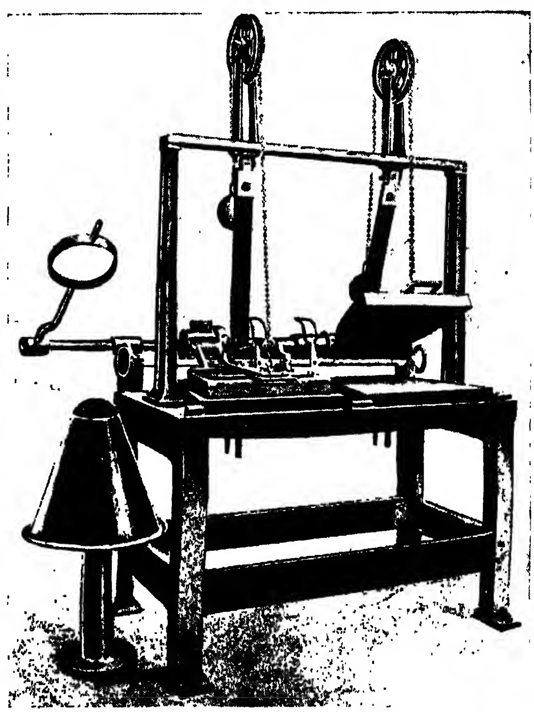
They are now given the finishing touches by hand at the battery, after which they are put into hot water and washed to free them from the sulphuric acid, used in planking to assist the process of felting. Now they are placed on a wooden cone-shaped block to free them from the marks that have been caused by doubling them in planking. They are then placed in the stove to dry. We have now reduced the hat from 14 in. by 21 in. to 9¾ in. by 15¾ in. The best bodies are produced by the subtlest of all machines—the human hand. No machine yet contrived for body-making can equal the fine machinery of the human fingers.

Stiffening the Shape. The next process is that of "proofing," or "stiffening," so that the hat will retain its shape, and become impervious to rain. For this purpose a double-jacketed pan is required, to dissolve the necessary ingredients, heated by steam, in which place 14 lb. of resin, 6½ lb. of borax, 60 lb. of button shellac, and 20 qt. of water. Dissolve the resin and borax in the water before entering the shellac, and after the whole mass has dissolved shut off the steam and allow it to cool down a little; then add water until it is the strength required for the purpose of stiffening the hats. Two large mugs, or troughs, are now required, to be filled with proof of different strengths—the stronger for the brims, and the weaker for the crowns.

The hat bodies are still cone-shaped, and, to start proofing, take hold of the tip or crown with the left hand, immerse about 4 in. in the strongest proof, place it on the bench, and with a piece of wood about 6 in. square held in the right hand draw off the superfluous proof, then croze it, and repeat the operation. Now allow it to set while a few more brims are done. The hats are then dipped bodily into the weaker solution for the crowns, the "draw-board" being used to draw off the excess of proof. Then allow them to drain and set, after which they are placed in an iron steam-chest, containing cone-shaped stands. Put a dozen hats on each stand, cover with a cloth, close the chest, and turn on the steam, which must not be below 30 lb. pressure to the square inch. Allow them to remain 40 minutes, then shut off steam, and spread bodies to cool. Now put them in a stove heated to 120° F., where they remain three hours. Again steam for another 40 minutes at 30 lb. pressure to drive the proof to the interior of the body, so that the surface of the hat will be free from all foreign matter. After taking them from the steam-chest, allow them to cool. Take a stiff brush and brush the hats well, inside and out. Up to this time the hat body is yet of a conical shape; forming, hardening, planking, and proofing have followed each other in turn.

The hat is now taken to the "blocker," and by him the cone-shaped body is pulled out round the edge to develop the brim, and the upper part is widened out to form the tip and side crown.

Next fill a large tub with water, bring it to the boiling point; then dissolve 6 oz. bichromate of potassium, and 6 oz. of copper sulphate. After dissolving these in boiling water, put in 15 dozen hat bodies, keeping them on the move for 30 minutes, afterwards passing them through clean water. The process described is termed



12. THE "HARDENER"

"mordanting," which prepares the hat to receive the necessary colouring matter. By the time "mordanting" is finished the vat or dye-kettle should be ready to receive the hats. Take 36 lb. logwood, place it in a coarse bag, swing it in the dye-kettle, and allow it to boil until the dyeing material is extracted from it; then take it out and put into the vat $1\frac{1}{2}$ lb. verdigris and $1\frac{1}{2}$ lb. iron sulphate. This may be improved by the addition of 2 lb. indigo extract. See that all the materials are dissolved before putting in the hats. After putting in the goods, keep the solution near the boiling point for 90 minutes; by that time the hats should be of a good black. Then take them out of the vat, providing the necessary depth of colour has been got, and place them in a tub of cold water, and allow them to remain some time before washing them in warm water.

The hat is now returned to the blocker—a man working at a battery similar to that described in "planking"—who is provided with wooden blocks, the size and shape the hats are required. He softens the body in boiling water, then pulls it on the block and slips a cord over it to keep in position the part intended for the crown. He then softens the brim part, takes hold of the edge between fingers and thumb, working round the hat, and following with left hand flat on the brim until it is the required shape. He then dips it in cold water, takes it off the block, and allows it to drain before placing it in the stove to dry. When dry, brush it well with a stiff brush. The hats are now taken to the "presser," a man provided with iron moulds or dishes. He places the correct size and shape in a hydraulic press, puts the hat in a steam or gas oven to soften, then places it in the "dish," closes the press, and turns on the pressure of 400 lb. to the square inch. The presses are provided with indiarubber bags containing the pressure, so that it may be evenly distributed over the whole surface of the hat.


13. PUTTING THE WOOL ON THE CONE


14. HYDRAULIC CURLING MACHINE

The Finishing Process. The "finisher" then takes the hat in hand, and on a quickly-revolving lathe smoothes its surface with glass-paper, afterwards polishing with tallow, dissolved by a gas heater and applied with a velure.

The rough edge is then cut from the brim by the rounding machine. Up to this time the hat brim is perfectly flat, but is now taken in hand by the curler, and placed on a steam baker, so that the brim only is softened, then put on a "split" frame, which is placed in the hydraulic curling machine [**14**]. After closing, the pressure is turned on from the accumulator, entering an indiarubber bag, by which it is distributed over the surface of the brim at the rate of 400 lb. to the square inch. The frames are made in all the shapes and sizes required, and being made in sections, they can be taken from the brim without altering the shape or breaking the curl. A hot iron is now run over the edge so that it will retain its shape; then cut the rough edges from the curl until it attains its proper dimensions.

It is next sent to the "trimming" department, where the brim is wired, the banding tied in a bow and fastened to the band of the hat, the binding sewn round the curl, and the leather and lining stitched and fastened in their respective positions by women, after which they are velured.

For illustrations **10**, **11** and **12**, we are indebted to the courtesy of Messrs. Turner, Atherton & Co., Ltd., Denton.

MEN'S HATS *concluded; followed by* FURS AND FURRIERS

ITALIAN–ESPERANTO–GREEK

Italian by F. de Feo; Esperanto by Harald Clegg; Greek by G. K. Hibbert, M.A.

ITALIAN

Continued from page 6235

By Francesco de Feo

DEFECTIVE VERBS

THOSE verbs that want some tenses or persons are called "defective." They are:

Angere (poet.), to grieve
Ind. Pres. (third pers. sing.).—*Ange.*

Ardire, to dare
The forms that might be confounded with the corresponding forms of the verb *àrdere,* to burn, as *ardiamo, ardente,* etc., are not used.

Arrogere, to add
Of this verb only the form *arroge* (imperat.) is now used.

Atterrire, to terrify
The forms that might be confounded with the corresponding forms of *atterrare,* to cast to the earth, as *atterriamo, atterriate,* are not used. This verb has no present participle.

Calére (impers.), to matter
Ind. Pres. (third pers. sing.).—*Cale.*
Imperf.—Caleva.
Past Def.—Calse.
Subj. Pres.—Càglia.
Imperf.—Calesse.
Gerund—Calendo.
Past Part.—Caluto.
Of this verb only the third persons of the present, imperfect, and past def. are sometimes used.

Capére, to hold [see page 4504]
Ind. Pres. (third pers. sing.).—*Cape;* plur., *càpono.*

Colere, to worship
Ind. Pres.—Coli, cole (poet.).
Past Part.—Colto and *culto.*

Gire (poet.), to go
Ind. Pres.—Gite.
Imperf.—Giva and *gìa.*
Past Def.—Gisti, gì, gimmo, giste, gìrono.
Subj. Imperf.—Gissi.
Future—Girò.
Condit.—Girei.
Past Part.—Gito.

Ire (poet.), to go
Ind Pres. and *Imperat.* (second pers. plur.).—*Ite.*
Imperf.—Ivo, ivi, iva; third pers. plur., *ìvano.*
Past Def.—Isti, ìrono.
Past Part.—Ito (gone).
The compound tenses are formed with *èssere*—as, *Se n'è ito,* He has gone.

Licere (poet.), to be allowed
Ind. Pres.—Lice (*lece*).
Imperf.—Liceva, licèvano.
Subj. Imperf.—Licesse, licèssero.
Past Part.—(*Lìcito*) *lècito.*

Lucere, to shine
Ind. Pres.—Luce, lùcono.
Imperf.—Luceva, lucèvano.
Pres. Part.—Lucente.

Molcere (poet.) to mollify, to mitigate
Ind. Pres.—Molci, molce.
Imperf.—Molceva.
Subj. Imperf.—Molcessi.
Gerund—Molcendo.
This verb has no past participle.

Olire (poet.), to smell sweet
Ind. Pres.—Olisci, olisce.
Imperf.—Oliva.
Pres. Part.—Olente.

Redire, to go back
Imperf.—Rediva, redivano.
Past Part.—Redirono.

Riedere, to go back
Ind. Pres.—Riedo, riedi, riede, rièdono.
Subj. Pres.—Rieda, rièdano.
Subj. Imperf.—Riedesse, riedèssero.

Sèrpere, to wind about
Ind. Pres. (third pers. sing.).—*Serpe.*
Instead of *sèrpere,* the verb *serpeggiare* is generally used.

Solére, to be accustomed
Ind. Pres.—Soglio, suoli, etc.
Subj. Pres.—Sòglia.
Past Part.—Solito [see page 4504].

Sùggere (poet.), to suck
This verb has no past part. Instead of *sùggere,* in colloquial language, *succhiare* and *succiare* are used.

Tàngere (poet.), to touch
Ind. Pres. (third pers. sing.).—*Tange.*
Subj. Pres.—Tanga.
Pres. Part.—Tangente

Urgere (impers.), to urge
Ind. Pres.—Urge, ùrgono.
Imperf.—Urgeva, urgèvano.
Subj. Imperf.—Urgesse, urgèssero.
Future.—Urgerà, urgeranno.
Condit.—Urgerebbe, urgerèbbero.
Pres. Part.—Urgente.
Gerund—Urgendo.
In familiar language the verb *èssere* followed by the pres. part. *urgente* is used.

Vertere, to be question of
Ind. Pres.—Verte, vèrtono.
Imperf.—Verteva, vertèvano.
Pres. Part.—Vertente.
Gerund—Vertendo.

Vigere, to be extant
Ind. Pres.—Vige, vìgono.
Imperf.—Vigeva, vigèvano.
Future—Vigerà, vigeranno.
Subj. Imperf.—Vigesse, vigèssero.
Pres. Part.—Vigente.
Gerund—Vigendo.
All the forms of this verb belong to the official language.

PROPOSITIONS

Attributive and Appositive Propositions. Attributive and appositive propositions are constructed with the relative pronouns *che, il quale, la quale,* etc., and they generally require the indicative, as: *Le accludo la lèttera che ho ricevuta,* I enclose you the letter that I have received.

But when the attributive proposition has the meaning of a final or consecutive proposition, the subjunctive must be used, as: *Si era comprato un ombrello, che le servisse* (*affinchè le servisse; tale che le servisse*) *anche da parasole*, She had bought an umbrella which she could also use as a sunshade.

Temporal Propositions. Temporal propositions are constructed with the conjunctions *quando, allorchè, appena, finchè, qualora*, etc., and they require the indicative if a fact is expressed as real or past; and the subjunctive (or the future of the indicative), if they refer to a possible or future fact, as: *Quando si è commesso un errore, bisogna pensare a rimediarvi*, When one has made a mistake, one must think of how to correct it; *Appena sentì il campanello, si precipitò giù ad aprire*, As soon as she heard the bell, she rushed down to open [the door]; *Aspetterò finchè fàccia* (or *farà*) *giorno*, I shall wait until it is day; *Capii tutto prima che aprisse bocca*, I understood everything before he opened his mouth.

Instead of the conjunction *quando*, we sometimes use the past participle followed by *che*, and the auxiliary verb, as: *Giunto che fui* (*quando giunsi*) *domandai di lui*, When I arrived I asked for him; *Finito che ebbe di mangiare* (*quando finì* or *ebbe finito*) *andò a fare una passeggiata in giardino*, When he had finished eating, he went for a walk in the garden.

These propositions are also constructed with the gerund or the infinitive preceded by prepositions, as: *Lo incontrammo andando* (*mentre andavamo*) *a teatro*, We met him while we were going to the theatre; *Nel fare una cosa* (*mentre fàccio*) *dimèntico l'altra*, In doing one thing I forget the other; *Detto ciò* (*avendo detto ciò; dopo che ebbe detto ciò*) *andò via*, After he had said this he went away.

Note. In Italian the gerund is never preceded by prepositions.

Local Propositions. Local propositions are constructed with adverbs of place, *dove, dovunque*, etc. They require the indicative, and, if the meaning is indefinite, also the subjunctive, as: *Vado dove mi pare e piace*, I am going where I like; *Dovunque batte* (*batta*) *cuor di popolo, i pòsteri leggeranno Garibaldi* (*Bovio*), Wherever the heart of a people beats, posterity will read of Garibaldi; *Dovunque il guardo io giro* (*giri*), *Immenso Dio ti vedo*, Wherever I turn my glance, I see Thee, Almighty God!

Causal Propositions. Causal propositions are constructed with the conjunctions *perchè, giacchè*, etc., and they require the indicative, and sometimes the conditional, as: *Non scherzare col fuoco, perchè altrimenti ne resterai* (or *ne resteresti*) *bruciato*, Do not play with the fire, because otherwise you will be burned.

The subjunctive is used when the subordinate proposition depends upon a negative, as: *Lo fàccio, non perchè ne àbbia voglia, ma perchè sono costretto a farlo*, I do it, not because I wish, but because I am compelled.

When a causal proposition has the same subject as the principal one, and the verb is in a past tense, the infinitive or the gerund may be used, as: *Per volèr troppo* (*perchè voleva troppo*) *non ebbe nulla*, He had nothing, because he wanted too much; *Avèndolo visto così afflitto* (*perchè lo vidi*) *credetti opportuno di non dirgli niente*, Seeing him so afflicted, I thought it wise not to tell him anything.

Final Propositions. Final propositions are constructed with the conjunctions *acciocchè, affinchè, perchè, che*, etc. The verb must always be in the subjunctive. If the verb of the principal proposition is in the present, past indefinite or future, the verb of the final proposition is in the present or past indefinite; if the verb of the principal proposition is in the imperfect or conditional the verb of the final proposition is in the imperfect or pluperfect. Examples: *Lo dico a te, perchè tu lo dica a lui*, I tell it to you, so that you may tell him; *Il ragazzo fingeva di dormire, affinchè la madre non lo sgridasse*, The boy pretended to be asleep in order that his mother might not scold him.

When the principal and the final propositions have the same subject, the aim is expressed by the infinitive preceded by *per*; so if we turn the final proposition of the above example into the passive, we must say: *Fingeva di dormire per non èssere sgridato da sua madre.*

Comparative Propositions. Comparative propositions are constructed with *che non*, or with *di quello che*, and they may be used with either the indicative or the subjunctive: as, *Ho guadagnato più che non sperassi* (or *di quello che sperassi*), I have gained more than I hoped; *La nèbbia divenne più spessa che non era prima* (or *che non fosse prima; di quello che era*, or *fosse prima*), The fog became thicker than it was before.

Note. *Che non* is used only before a verb, as in the above examples; in any other case the *non* is omitted: *Uccide più la gola che la spada*, Gluttony kills more than the sword; *Egli ha speso più parole che danaro*, He has spent more words than money.

After the relative superlative, the subjunctive is used: *È la più bella donna che io àbbia mai veduta*, She is the most beautiful woman I have ever seen; *Questo è il più gran ponte che sia mai stato costruito*, This is the largest bridge that was ever built.

Conditional Propositions. Conditional propositions are constructed with *se, purchè, caso mai, qualora, quando, dove*, etc. With the conjunction *se*, the verb is in the indicative if the condition is assumed to be real; and in the subjunctive if the condition is only imaginary: *Se avete volontà di lavorare, vi prenderò nel mio ufficio*, If you are willing to work, I will take you into my office; *Se lo sapessi, ve lo direi*, If I knew it, I would tell you.

With other conjunctions and adverbs, the subjunctive is generally used: *Quando tutto vada bene, non avrò guadagnato nulla*, If everything goes well, I shall have earned nothing; *Noi non vogliamo fargli del male, purchè àbbia giudìzio*, We do not wish to do him any harm, provided he is (be) reasonable.

Conditional propositions may also be constructed with the infinitive, preceded by prepositions, with the gerund, and the past participle: *A dire il vero* (*se vogliamo dire il vero*) *non ci aspettavamo tanto successo*, To tell the truth, we did not expect so much success; *Vedèndolo* (*se lo vedi*), *digli che l'aspetto*, If you see him, tell him that I am waiting for him; *È una spècie di mùsica che, eseguita bene* (*se fosse eseguita bene*), *potrebbe passare*, It is a kind of music that, if well executed, might pass.

Concessive Propositions. Concessive propositions are constructed with *benchè, sebbene, quantunque, non ostante che, per quanto, se anche, quando anche, con tutto che*, etc.

The verb is in the subjunctive: *Egli ha sempre qualche cosa da dire a tutti, quantunque nessuno gli voglia dare ascolto*, He always has something to say to everyone, although no one wishes to listen to him: *Quando anche dovessi pèrdere tutto quello che ho, non abbandonerei l'impresa*, Even if I had to lose all I possess, I would not give up my enterprise.

Consecutive Propositions. Consecutive propositions are constructed with *che, a segno che,*

tanto che, di maniera che, di guisa che, etc. The verb is in the indicative if the consequence is expressed as a fact, and in the subjunctive if the consequence is only considered as possible: *Ha insistito tanto, che ha ottenuto quello che voleva,* He has insisted so much that he has obtained what he wished: *Disponete le cose in modo che vi sia un certo òrdine,* Arrange the things in such a way that there may be a certain order.

Consecutive propositions may also be constructed with the infinitive preceded by the preposition *da: Gli mìsero tanta paura addosso, da farlo stare rinchiuso in casa per un mese intero,* They frightened him so much, that he remained indoors for a whole month.

NOTE. With *troppo,* the preposition *per* is generally used: *Egli è di cuore troppo nòbile, per scéndere a una tale bassezza,* He has too good a heart to descend to any such meanness.

KEY TO EXERCISE LV.

1. I heard someone knocking; I opened [the door], but I did not see anyone. 2. "May God bless you," said the poor mother. 3. When Mr. N. returns to the office, I will tell him that you called. 4. If you had told me the truth, I would have forgiven you. 5. We offered him five hundred francs, but he did not wish to accept. 6. If you do not mind going up to the fourth floor, I will show you the violin of which I spoke to you the other day. 7. Tell your cousin to come to me to-morrow, because I want to speak to him. 8. You cannot believe how much that unhappy man has suffered! 9. This bridge was constructed four hundred years ago.

Continued

ESPERANTO

Continued from page 6238

By Harald Clegg

Participial Adjectives

PASSIVE VOICE

The passive voice in Esperanto is formed by the addition of the participial endings *ata* (present), *ita* (past), and *ota* (future) to transitive verbs. Intransitive verbs are incapable of receiving these.

The rules for the formation of the compound tenses of the passive voice are exactly the same as those for the active voice. When used predicatively the participles accord with the noun or pronoun in number only. When used to qualify, they agree in number and case.

Nine compound tenses may be obtained by combining the three passive participles with the three tenses of the auxiliary verb *esti.* (These three participles may also be combined with *esti, estus* and *estu.*)

Mi estas lavata, I am (being) washed; *mi estas lavita,* I have been washed (lit. I am having been washed); *mi estas lavota,* I am about to be washed.

Mi estis lavata, I was (being) washed; *mi estis lavita,* I had been washed (lit. I was having been washed); *mi estis lavota,* I was about to be washed.

Mi estos lavata, I shall be (being) washed; *mi estos lavita,* I shall have been washed (lit. I shall be having been washed; *mi estos lavota,* I shall be about to be washed.

Mi estus lavata, I should be (being) washed; *mi estus lavita,* I should have been washed (lit. I should be having been washed); *mi estus lavota,* I should be about to be washed.

The present, past, and future infinitives are: *Esti lavata,* to be (being) washed; *esti lavita,* to have been washed; *esti lavota,* to be about to be washed.

The complement of the passive voice is introduced by *de* (by) to indicate the agent, and by *per* (by means of, with) to indicate the instrument:

Mi estis lavata de mia patrino per sapo, I was (being) washed *by* my mother *with* soap.

The distinction of these prepositions is sometimes a little obscure, but if it be remembered that *de* must be used to introduce the performer of the action, and that *per* indicates the means or method used, a little forethought will determine which preposition must be used.

Example: *Mi estis kovrita de la knaboj per koto,* I was covered with mud by the boys. *La leteroj estis skribitaj de ŝi per plumo,* The letters were written by her with a pen.

The simple tenses will show more clearly the *agent* and the *instrument:*

The boys covered me with (*per*) mud; She wrote the letter with (*per*) a pen.

Suffixes

AD denotes the continuation or repetition of an action.

Example: *Promeni,* to walk; *promenadi,* to walk about; *instrui,* to instruct; *instruado,* instruction; *pafo,* a shot; *pafado,* a fusillade.

ID denotes a child or descendant, also young of animals.

Example: *Princo,* prince; *princido,* prince's son; *princidino,* prince's daughter; *koko,* cock; *kokido,* chicken.

IST denotes a person following the occupation indicated by the root-word.

Example: *Paroli,* to speak; *parolisto,* a professional speaker, a lecturer, an orator.

Note the customary habit here. An occasional speaker would be indicated by the use of the participles *parolanto, parolinto,* or *parolonto,* according to whether the time referred to be present, past or future.

ESTR denotes a chief or leader (not a master).

Example: *Ŝipo,* ship; *ŝipestro,* captain; *klubo,* club; *klubestro,* leader of a club.

Master of an hotel is *hotelmastro,* not *hotelestro.*

Vocabulary

anas', duck
anser', goose
art', art
benk', bench
buĉ', butcher (v. t.)
ĉarpent', carpentry
ĉerp', draw, extract
denunc', denounce
esplor', explore
fleg', nurse, take care of
forĝ', forge (v.t.)
juĝ', judge (v.t.)
komerc', commerce, trade
komiz', clerk
kondamn', condemn
kort', courtyard
kugl', bullet
kurac', treat, cure
paŝt', pasture, feed cattle
pot', pot (earthen)
predik', preach
rab', rob
rajt', right
rekomend', recommend
rigl', bolt (v. t.)
rimed', remedy, means
ring', ring (subst.)
sang', blood
sap', soap
sat', satiated
seĝ', seat, chair
serv', serve
sever', severe
situaci', situation
skulpt', sculpture (v.t.)
sonĝ', dream
spec', kind, sort
stel', star
suker', sugar
suspekt', suspect (v. t.)
ŝaŭm', foam
ŝpin', spin (threads)
ŝtat', state (country)
teks', weave
tent', tempt
traduk', translate
ver', true
verd', green
verk', work (literary)
vers', verse

Exercise XVII.

1. Servistino, kokidaro, kuracisto, rabistestro, ŝpinisto, tentado, ĉarpentisto, buĉisto, servado, flegistino, anasido, esploristo, paŝtisto, artistino, hundido, ĉevalidino, skulptisto, kuracistino, predikado. La rabistaro estis kondamnita de la juĝisto. Verkisto verkas librojn kaj skribisto simple transskribas paperojn. Ili aŭdis la pafadon kaj la kuglojn flugantajn. La komizo estas konfesinta, ke li prenis la ringon, kaj nun li estas juĝota de la juĝisto. Kiam la ŝpinistino estis malsana, la kuracisto vizitis ŝin, sed, post iom da tempo ŝi mortis. La fero estis forĝata de la forĝisto.

2. This is the remedy which is recommended by the sailor. The door was locked against the robber. The suspected person has been denounced by the clerk, and he will certainly be severely punished. These verses were extracted by the translator (professional) from the works of the best writers. Some stood on chairs and benches in order to see better, but the orator could not be heard. It is not possible to see a flying bullet. He was dreaming about his far away home, which, possibly, he would (will) never see more. Nobody has the right to judge. Remember that he who judges will be judged. Now it is night, and we can see the shining stars above the foaming sea. Friends seldom seen are friends forgotten.

Note. The participles to be used in translating.

Participial Nouns and Adverbs

Active Voice

In the two foregoing lessons the formation of adjectival participles, active and passive, has been explained. There remain, however, two other participial forms, obtained by substituting *o* or *e* for the final *a*, by which change we get substantives and adverbs respectively. Examples:

Lavanto, the person or thing that is performing the action expressed in the root.

Lavinto, the person or thing that *has performed* the action expressed in the root.

Lavonto, the person or thing which is *about to perform* the action expressed in the root.

Lavante, while washing.

Lavinte, after having washed.

Lavonte, when about to wash.

The term adverb in Esperanto has a much wider application than in English. Not only roots, but their derivatives can be made into adverbs by the addition of the adverbial termination *e*. Thus, a phrase may be represented by one word, as. *elirinte*, having gone out.

The adverbial form, being exceedingly convenient and expressive, is much used in Esperanto, but its functions must be carefully noted, as the adverbs so constructed may only relate to the subject of the sentence in which they actually appear.

Example: *Lavinte sin, la knaboj iris al la teatro*, Having washed themselves, the boys went to the theatre; *Estante saĝaj, ili tuj konsentis*, Being wise, they at once consented.

But when, however, such an adverbial phrase in English does not relate to the subject of the sentence, then the meaning must be expressed in Esperanto in a different manner. The sentence: "I having been wounded, the doctor visited me," cannot be translated by *Vundite, la kuracisto min vizitis*, because here the subject of the sentence is *la kuracisto*, by which it would appear that *la kuracisto* was wounded. Such a sentence must be translated *Ĉar (aŭ kiam) mi estis vundita la kuracisto vizitis min*, "As (*or* when) I had been wounded, the doctor visited me."

In English sentences the word *after* is very often placed before the gerund: "After eating, I slept well." The Esperanto past participle, however, fully expresses time, and consequently *after* must not be translated: say *Manĝinte, mi bone dormis.*

The word "without" before the participles is rendered by *ne*.

Ne pensante, mi sendis la leteron, Without thinking, I sent the letter; *Ne pentinte, li mortis*, Without having repented, he died.

Extraneous Words

There exist, in use throughout the world, a large number of words, principally scientific and technical, which, derived from a common source, have already become international. The fundamental vocabulary of Esperanto need not, therefore, be swollen by their inclusion, inasmuch as a very slight phonetic and orthographic adjustment turns them into suitable Esperanto words. But since Esperanto is primarily intended for those who have not acquired foreign languages, and, therefore, are not in a position to judge what words are international, nor to discriminate between concurrent cognate words, the best dictionaries are gradually including these words in their approved forms.

Such words are:

telefono, telephone
markonigram-e, by marconigram
omnibus-i, to go by omnibus
helium-o, helium
teleskop-o, telescope
aŭtomobil-e, by motor-car
telefon-inda, worth telephoning
mikrofon-a, microphonic

Vocabulary

acid', acid, sour
anim', soul
atest', attest, affirm
azen', ass, donkey
buton', button
dec', becoming, decent
desegn', design, draw
difin', define
drap', cloth, woollen goods
ekscit', excite
embaras', embarass
fend', split, rive
fleks', bend (v.t.)
fundament', foundation
hered', inherit
kadr', frame
komod', chest of drawers
kompost', compose (printing)
konscienc', conscience
lang', tongue
lign', wood (substance)
mason', build with stone
maŝin', machine
mebl', piece of furniture
migr', migrate
ornam', adorn
ost', bone
pik', prick, sting
plad', dish, plate
plat', flat
porcelan', porcelain
prefer', prefer
prepar', prepare
prezent', present (v. t.)
privat', private
prudent', reasonable
rand', edge
reg', rule, govern
rilat', relate to
rost', roast (v.t.)
sag', arrow
sankt', sacred
senc', sense
sid', sit
signif', signify, mean
societ', society
sonor', give out a sound (as bell)
sort', fate, end, lot
spert', expert
sprit', wit
stat', state, condition
ŝpar', spare save

Exercise XVIII.

I shot an arrow into the air, but having lost it, I conclude that I am not an expert. This set of exercises, after having been printed by a linotype machine, is now ready. In painting that picture, and drawing this design, he attracted much attention. You have spoken (a piece of) nonsense. Having admired the beauty of the furniture and ornaments, they presented a silver coin to the doorkeeper. Steel is flexible, but iron is not flexible.

All the emigrants wasted their money, and having arrived in a pitiable state, they excitedly complained about their misfortune. That singer is worth neither hearing nor seeing. The writer of this letter is the first witness. After finishing his meal, he rang. Here is the roast beef. Do you prefer veal, mutton, or lamb, sir? That sort of wittiness signifies nothing. Take away this sour stuff. When the mason was about to die, his inheritors came to receive his blessing and divide his fortune. Their rapidity afterwards pricked their consciences. It is better to die poor than unloved. The proposal was carefully prepared, and afterwards presented to the society-membership. You would be much embarrassed if you knew how imprudent he is. The tree was split by the woodman with an axe. I can conscientiously affirm that.

Participial Nouns and Adverbs

PASSIVE VOICE

The participles in the passive voice may, in the same way as those in the active voice, take the substantival and adverbial forms:

SUBSTANTIVES:

Lavato, the person or thing *being washed*.

Lavito, the person or thing (*having been*) *washed*.

Lavoto, the person or thing *about to be washed*.

ADVERBS:

Lavate, in being washed.

Lavite, having been washed.

Lavote, being about to be washed.

These adverbial participles must always relate to the subject of the sentence in which they appear.

Examples: *Vundite, li alvokis helpon*, On being wounded, he called for help; *Kaŝite, la ringo ne povas esti trovata*, Having been hidden, the ring cannot be found; *Batote de l'patro, la infano ploris*, About to be beaten by the father, the child cried.

The remarks on the construction and general use of participial adverbs in the active voice apply equally to the adverbs in the passive voice.

KEY TO EXERCISE XVI.

Forte blovas ekstere. Kiam li estis faldinta la fakturon kaj skribinta sian adreson sur la koverton, li donis ambaŭ al mi. Kia stranga vetero estas hodiaŭ! Jen neĝas, jen hajlas, jen fulmas kaj tondras. Oni neniam povas esti certa pri ĝi. Tiu ĉi ĉeno havas tridek sep ĉenerojn, ĉiu el oro. Li ne ŝatas la frostan veteron, kaj estas ĉiam feliĉa kiam ekdegelas. Li estis defendanta. Ili estas melkontaj. Mi estos ŝanĝinta. Ni ne estas pretendantaj. Vi estos savinta (aŭ savintaj), Li estis defendonta. Mi estis ofendinta. Ili estos ripozintaj. Mi estas ordoninta. Ŝi estas spiranta. Tiuj kiuj estas mortontaj vin salutas. Ili estas ofendintaj min. Ili estis tuj savontaj ŝin. La vilaĝanino estis melkinta siajn bovinojn. La policano estas trankvile dormanta. Mi sentas min kvazaŭ mi esti mortonta. Se mi havus ombrelon, mi estus povinta (aŭ, povus) viziti vin malgraŭ la pluvo. Polvero estis falinta en ŝian okulon. Ŝi estis tremanta, kaj apenaŭ povis spiri. Se ili scius la regularon, ili ne estus farintaj (aŭ, farus) dufoje la saman eraron. La blindulo estis falonta en la flamojn, kiam tiu kuraĝulo savis lin.

Continued

GREEK

Continued from page 6240

By G. K. Hibbert, M.A.

SECTION I.—PREPOSITIONS

The prepositions in Greek, as in English, were originally adverbs, and this adverbial use is clearly seen when prepositions appear in composition with verbs—*e.g.*, *κατα-βαίνω*, I go down. The Greek prepositions govern various cases, as will be seen from the following scheme:

I. GENITIVE ONLY: *ἀντί*, *ἀπό*, *ἐκ* (*ἐξ* before a vowel), and *πρό*.

ἀντί, instead of, for the sake of—as: *ἀντί σου*, instead of you, *or* for your sake. In composition with a verb it means *against* (*ἀντειπεῖν*, to speak against); *instead* (*ἀντιλαμβάνειν*, to receive instead); *in return* (*ἀντιδίδωμι*, I give in return).

ἀπό (Latin *a, ab*; English *off*), from, away from—as: *ἀπὸ τούτου τοῦ χρόνου*, from this time; *ἀφ' ἵππου μάχεσθαι*, to fight from a horse—*i.e.*, on horseback. In composition with a verb it means *from, away, in return*—as: *ἀποστέλλω*, send away ("apostle").

ἐκ (Latin *e, ex*), from, out of—as: *ἐκ ταύτης τῆς πόλεως φεύγει*, He is banished from this city; *ἐκ τοῦ νῦν*, from the present (time); *Ὄναρ ἐκ Διός ἐστιν*, The dream is from Zeus. In composition, it means *out, away*—as: *ἐκπίπτω*, I am driven out (lit. I fall out, used as the passive of *ἐκβάλλω*, I expel).

πρό (Latin *pro*), before, on behalf of—as: *πρὸ τοῦ νεώ*, before the temple; *πρὸ τῆς μάχης*, before the battle; *πρὸ πατρίδος μάχεσθαι*, to fight for fatherland; *πρὸ τούτων*, in preference to this. In composition it means *before, forth*—as: *προκαλέω*, call forth.

II. DATIVE ONLY: *ἐν* and *σύν*.

ἐν (Latin *in* with ablative), in—as: *ἐν τῇ νήσῳ*, in the island; *ἐν τούτῳ*, meanwhile (understanding *τῷ χρόνῳ*); *ἐν δήμῳ λέγειν*, to speak among the people. In composition it means *in, on* (*ἔγκειμαι*, I lie on).

σύν or *ξύν* (Latin *cum*), together with, with the help of—as: *σὺν τοῖς θεοῖς*, with the help of the gods; *σὺν Ξενοφῶντι ἐπορεύετο*, He went with Xenophon. In composition it means *with, together*—as: *συμμάχομαι*, fight along with. (This preposition appears in our English words beginning with syn, sym, syl, sys, etc.).

III. ACCUSATIVE ONLY: *εἰς* or *ἐς*, into, to (Latin *in* with accusative)—as: *εἰς Ἀθήνας ἔφυγον*, They fled to Athens; *εἰς νύκτα*, till night; *εἰς ἕκατον*, up to a hundred; *χρήσιμος εἰς πόλεμον*, useful for war.

The form *ὡς* is sometimes found, but only with persons: *ὡς Κῦρον εἰσιέναι*, to go to visit Cyrus.

IV. ACCUSATIVE AND GENITIVE: *διά*, *κατά*, *ὑπέρ*.

διά, through. 1. With accusative *on account of*: *διὰ τοῦτο*, on this account; *διὰ τὴν νόσον*, on account of the disease. 2. With genitive *through*; *διὰ νυκτός*, through the night; *διὰ τῆς χώρας*, through the country; *δι' οὐδένος ποιεῖσθαι*, to value at nothing; *δι' ὀργῆς ἔχειν*, to be in anger (*ἔχειν* is often used intransitively = to be).

In composition it means *through, in different directions, mutually*—as: διαρρίπτω, throw in different directions.

κατά, down. 1. With accusative *down along, at* (of time), *according to, by* (distributively)—as: κατὰ ῥοῦν, down stream; οἱ καθ' ἡμᾶς, those at our time; κατ' ἐμέ, according to me; καθ' ἡμέραν, day by day; κατὰ τρεῖς, by threes. 2. With genitive *down from, below, against*—as: κατὰ γῆς, below ground; κατὰ τῆς πέτρας ἅλλεσθαι, to leap down from the rock; κατά τινός λέγειν, to speak against someone In composition *down, against:* καταβαίνω, go down; καταψεύδομαι, tell lies against.

ὑπέρ, over (Latin *super;* note that a rough breathing in Greek is often represented by *s* in Latin: ἕξ, sex; ἑπτά, septem; ἅλς, sal). 1. With accusative *beyond*—as: ὑπὲρ δύναμιν, beyond one's strength. 2. With genitive *above, on behalf of*—as: ὑπὲρ τῆς κεφαλῆς, over his head; μάχεσθαι ὑπέρ τινος, to fight for someone. In composition *over, exceedingly, on behalf of.* (English *hyper*, as in "hyper-critical").

V. Accusative, Genitive, and Dative: ἀμφί, ἐπί, μετά, παρά, περί, πρός, ὑπό (and very rarely ἀνά).

ἀμφί, about (Latin *amb-, both*), on two sides of. 1. With accusative *about* (time, space, number, or circumstances)—as: οἱ ἀμφὶ Πλάτωνα, those about Plato (*i.e.*, the Platonists); ἀμφί τι ἔχειν, to be busy about a thing. 2. With genitive *about* (of subject matter), rare in prose; usually περί. 3. With dative *about* (of place), *for the sake of, owing to*—as: ἀμφ' Ἑλένῃ μάχεσθαι, to fight for Helen; ἀμφὶ φόβῳ, for very fear.

ἐπί, on, upon. 1. With accusative *on to, to, towards, against*—as: προελθεῖν ἐπὶ τὸ βῆμα, to come forward on to the platform; πλεῖν ἐπὶ τοὺς Ἀθηναίους, to sail against the Athenians. Also in phrases like τὸ ἐπ' ἐμέ, as far as I am concerned; ἐπὶ τοῦτο, for this purpose; ἐπὶ τὸ πολύ, for the most part. 2. With genitive *on, towards, in the time of*—as: ἐπὶ βήματος, on a platform; ἐπὶ Σάμου πλεῖν, to sail towards Samos; ἐφ' ἡμῶν, in our time. 3. With dative *on, at, on condition of, in the power of, in addition to*—as: τὸ ἐπ' ἐμοί, so far as is in my power; ἐπὶ τούτοις, on these terms, *or*, in addition to this; μέγα φρονεῖν ἐπί τινι, to be proud of a thing.

μετά, among, with (akin to Latin *medius*). 1. With accusative *after*—as: μετὰ τὸν πόλεμον, after the war; μετὰ ταῦτα, thereafter. Also rarely (in poetry) it = into the midst of—as: μετὰ στρατόν, into the midst of the host. 2. With genitive *with, on the side of* (implying closer union than σύν)—as: μετά τινος πάσχειν, to suffer with someone; μετ' Ἀθηναίης, with the help of Athena. 3. With dative *among* (only used in poetry)—as: μετὰ κύμασι, among the waves (Homer). In composition μετά often denotes *change*—as: μεταμόρφωσις, transformation; μετανοέω, I change my mind, repent.

παρά, near, alongside. 1. With accusative *to the side of, along, during, because of, contrary to, compared with*—as: καταφυγὴ παρὰ φίλους, a flight to one's friends; παρὰ τὸν βίον ἅπαντα, during the whole of life; παρὰ τοῦτο γέγονεν, It has happened because of this; παρὰ φύσιν, contrary to nature; παρὰ πολύ, by far. 2. With genitive *from the side of, from*—as: ἄγγελος παρά τινος, a messenger from someone. 3. With dative *at the side of, near*—as: στῆναι παρά τινι, to stand by someone. In composition παρά often means *beyond, over, wrongly*—as: παρανομέω, I transgress the law.

περί, around, about. 1. With accusative *about, near* (practically the same as ἀμφί)—as: οἱ περὶ Κῦρον, Cyrus and his attendants. 2. With genitive *about, concerning* (Latin *de*), *above* (in poetry)—as: περί τινος λέγειν, to speak about someone; also the common phrase: περὶ πολλοῦ ποιεῖσθαι τί, to reckon a thing worth much. 3. With dative *around, about, by reason of* (rare in Attic prose)—as: θώρακα περὶ τοῖς στέρνοις ἔχειν, to have a breastplate round the breast; περὶ δείματι, for fear (Latin *præ*). In composition περί often denotes excess—as: περικαλλής, very beautiful; περιδείδω, I fear exceedingly (*cf.* Latin *permagnus*, exceeding great).

πρός, in front of, at, by. 1. With accusative *to, towards, against, in reference to*—as: κλαίειν πρὸς οὐρανόν, to cry to heaven; πρὸς Θεὸν ἐρίζειν, to strive against God; πρὸς ἑσπέραν, towards evening; πρὸς τὸν λόγον, in reference to the argument; and often adverbially—as: πρὸς βίαν, = βιαίως, forcibly. 2. With genitive *from* (rare), *by* (of agent), *in the eyes of*, and in oaths—as: τετιμῆσθαι πρός τινος, to have been honoured by someone; πρὸς ἀνθρώπων, in the eyes of men; πρὸς Θεῶν, by the gods (I swear); also in sentences like Οὐ πρὸς ἰατροῦ σοφοῦ θρηνεῖν, It is not the part of (*or* it is not fitting) a wise physician to wail. 3. With dative *at, near, in addition to*—as: τεῖχος πρὸς τῇ θαλάσσῃ, a wall near the sea; πρὸς τούτοις, in addition to this, furthermore.

ὑπό (Latin *sub*), under, by. 1. With accusative *to under, towards* (of time)—as: ἰέναι ὑπὸ γαῖαν, to go under the earth (*i.e.*, to die); ὑπὸ νύκτα, towards night (Latin *sub noctem*). 2. With genitive *from under, through* (causal), *by* (of agent, after passive verbs; Latin *ab*)—as: λύειν τοὺς ἵππους ὑπὸ τοῦ ζυγοῦ, to loosen the horses from under the yoke; ὑπὸ δέους, through fear; τιμᾶσθαι ὑπὸ τῶν πολιτῶν, to be honoured by the citizens; also in such phrases as: ὑπ' αὐλοῦ, to the accompaniment of the flute. 3. With dative *at, under* (place and circumstances)—as: εὕδειν ὑπὸ πέτρῃ, to sleep beneath a rock. In composition ὑπό often means *secretly*, or *slightly*, or *gradually*—as: ὑποθέω, I make a secret attack; ὑπόλευκος, somewhat white.

ἀνά, up (opposite of κατά). 1. With accusative *up, along*—as: ἀνὰ τὸν ποταμόν, up the river; ἀνὰ νύκτα, all night through. Distributively—as: Ἔστησαν ἀνὰ ἑκατόν, They stood in hundreds; ἀνὰ πεντήκοντα, by fifties. 2. With genitive, only in the phrase ἀνὰ νηὸς βαίνειν, to go on board ship (Homer). 3. With dative *on, upon* (only in poetry)—as: ἀν' ὤμῳ, upon the shoulder. In composition ἀνά denotes *up, back, repetition, strengthening*—as: ἀναχωρέω, I retreat.

In addition to the above, which are the prepositions proper, there are some adverbs used as prepositions. These cannot be compounded with verbs, and are called improper prepositions. They are: ἄνευ and ἄτερ, without; ἄχρι and μέχρι, as far as, until; μεταξύ, between; ἕνεκα,

for the sake of; πλήν, except. These all govern the genitive.

AUGMENT OF VERBS COMPOUNDED WITH PREPOSITIONS. In the case of a verb compounded with a preposition, the augment follows the preposition—as: προσλαμβάνω, προσέλαβον; ἐκλείπω, ἐξέλιπον; εἰσακούω, εἰσήκουσα; συγκρίνω, συνεκρίθην; συλλαμβάνω, συνέλαβον; συμβάλλω, συνέβαλον; συ-στέλλω, συνέσταλκα.

Prepositions that end in a vowel drop the final vowel before the augment ε, except περί and πρό—as: ἀποβάλλω, ἀπέβαλλον; but περιέβαλλον and προέβαλλον. (πρό is usually contracted with the augment—as: προὔβαλλον for προέβαλλον.)

A few verbs take the augment before the preposition—as: καθίζω, ἐκάθιζον; while some have both augments—as: ἀνέχω, ἠνειχόμην.

ὑποπτεύω, suspect, makes ὑπώπτευον; and παρανομέω, transgress, makes παρηνόμουν (very irregular).

The Irregular Verbs εἰμί, Be, and εἶμι, Go.

εἰμί (stem ἐσ-, Latin *es-se*), be.

Indicative

Present	*Imperfect*	*Future*	*Present Subj.*	*Present Optative*	*Present Imperative*
εἰμί	ἦν or ἦ	ἔσομαι	ὦ	εἴην	—
εἶ	ἦσθα	ἔσει or ἔσῃ	ᾖς	εἴης	ἴσθι
ἐστί	ἦν	ἔσται	ᾖ	εἴη	ἔστω
ἐστόν	ἦτον	ἔσεσθον	ἦτον	εἴητον, εἶτον	ἔστον
ἐστόν	ἤτην	ἔσεσθον	ἦτον	εἰήτην, εἴτην	ἔστων
ἐσμέν	ἦμεν	ἐσόμεθα	ὦμεν	εἴημεν, εἶμεν	—
ἐστέ	ἦτε	ἔσεσθε	ἦτε	εἴητε, εἶτε	ἔστε
εἰσί	ἦσαν	ἔσονται	ὦσι	εἴησαν, εἶεν	ἔστωσαν, ἔστων, ὄντων

Present Infinitive: εἶναι, to be.

Present Participle: ὤν, οὖσα, ὄν (*gen.* ὄντος, οὔσης, ὄντος; *nom. pl.* ὄντες, οὖσαι, ὄντα), being.

Future Infinitive: ἔσεσθαι.

Future Participle: ἐσόμενος.

Verbal Adjective: ἐστέον.

There is also a future optative, ἐσοίμην, ἔσοιο, ἔσοιτο, etc., quite regular.

εἶμι (stem ἰ-, Latin *i-re*), go.

Present Indicative	*Imperfect Indicative*	*Present Subj.*	*Present Optative*	*Present Imperative*
εἶμι	ᾔειν or ᾖα	ἴω	ἰοίην	—
εἶ	ᾔεις or ᾔεισθα	ἴῃς	ἴοις	ἴθι
εἶσι	ᾔει or ᾔειν	ἴῃ	ἴοι	ἴτω
ἴτον	ᾔειτον or ᾖτον	ἴητον	ἴοιτον	ἴτον
ἴτον	ᾐείτην or ᾔτην	ἴητον	ἰοίτην	ἴτων
ἴμεν	ᾔειμεν or ᾖμεν	ἴωμεν	ἴοιμεν	—
ἴτε	ᾔειτε or ᾖτε	ἴητε	ἴοιτε	ἴτε
ἴασι	ᾔεσαν or ᾖσαν	ἴωσι	ἴοιεν	ἴτωσαν or ἰόντων

Infinitive: ἰέναι, to go.

Participle: ἰών, ἰοῦσα, ἰόν (*gen.* ἰόντος, etc.).

Verbal Adjective: ἰτός and ἰτέον.

NOTE. The present εἶμι has usually a future sense, I shall go, and is used as the future of ἔρχομαι. The two εἶμι's are liable to be confused by the beginner, and there is a third verb, οἶδα, know, which is somewhat similar in parts. Thus—

οἶδα, I know.

(οἶδα has no present, being a second perfect from the stem ἰδ-; see εἶδον in dictionary.)

Perfect Indicative	*Pluperf. Indicative*	*Perfect Imperative*
οἶδα	ᾔδειν or ᾔδη	—
οἶσθα	ᾔδεισθα or ᾔδεις	ἴσθι
οἶδε	ᾔδει or ᾔδη	ἴστω
ἴστον	ᾔδειτον or ᾖστον	ἴστον
ἴστον	ᾐδείτην or ᾔστην	ἴστων
ἴσμεν	ᾔδειμεν or ᾖσμεν	—
ἴστε	ᾔδειτε or ᾖστε	ἴστε
ἴσασι	ᾔδεσαν or ᾖσαν	ἴστωσαν

Perfect Infinitive: εἰδέναι, to know.

Perfect Participle: εἰδώς, εἰδυῖα, εἰδός, knowing.

Verbal Adjective: ἰστέον.

Subjunctive: εἰδῶ, εἰδῇς, εἰδῇ, etc.

Optative: εἰδείην, εἰδείης, εἰδείη, etc.

Future Indicative: εἴσομαι, εἴσει, εἴσεται, etc.

SECTION III.—TRANSLATION

THE FIRST GLIMPSE OF THE SEA

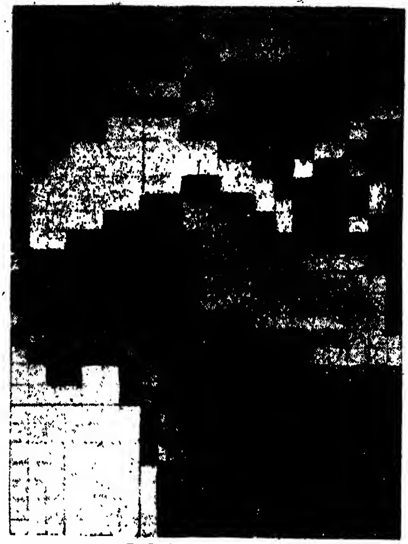
[This is from Xenophon's "Anabasis," one of the most fascinating books in the world. Xenophon has led a body of Greeks into Persia to help Cyrus to wrest the crown from his elder brother Artaxerxes II. Cyrus is slain, and the Greeks have to retreat. It is a time of terrible danger and hardship, and when one day in February 400 B.C. the vanguard catch sight of the Black Sea in the distance and call out "The Sea! The Sea!" the joy of the whole army is unbounded. Let the gallant leader tell the story in his own words.]

Ἐντεῦθεν ἐπορεύθησαν διὰ Χαλύβων καὶ ἦλθον (1) πρὸς πόλιν μεγάλην, ἣ ἐκαλεῖτο Γυμνίας. ἐκ ταύτης τῆς πόλεως ὁ τῆς χώρας ἄρχων πέμπει ἡγεμόνα τοῖς Ἕλλησιν· ἐλθὼν δὲ ἐκεῖνος εἶπεν ὅτι ἄξοι (2) αὐτοὺς εἰς χωρίον ὅθεν ὄψοιντο (3) θάλασσαν. ὁ δὲ ἡγεῖτο (4) αὐτοῖς· καὶ ἀφικνοῦνται ἐπὶ τὸ ὄρος τῇ πέμπτῃ ἡμέρᾳ· ἐπεὶ δὲ οἱ πρῶτοι ἐγένοντο (5) ἐπὶ τοῦ ὄρους καὶ κατεῖδον τὴν θάλασσαν, κραυγὴ πολλὴ ἐγένετο. ὁ δὲ Ξενοφῶν καὶ οἱ ὀπισθοφύλακες ἀκούσαντες ᾠήθησαν (6) πολεμίους ἐπιτίθεσθαι τοῖς ἔμπροσθεν. ἐπειδὴ δὲ βοὴ πλείων ἐγίγνετο, καὶ οἱ ἀεὶ ἐπιόντες (7) ἔθεον δρόμῳ ἐπὶ τοὺς ἀεὶ βοῶντας, ἐδόκει δὴ τῷ Ξενοφῶντι μεῖζόν τι εἶναι· καὶ ἀναβὰς ἐφ' ἵππον καὶ ἀναλαβὼν τοὺς ἱππέας, παρεβοήθει. (8) καὶ τάχα δὴ ἀκούουσι τῶν στρατιωτῶν βοώντων 'Θάλασσα, θάλασσα', καὶ παρακελευομένων ἀλλήλοις. ἔνθα δὴ πάντες ἔθεον· ἐπεὶ δὲ ἀφίκοντο ἐπὶ τὸ ἄκρον, ἐνταῦθα δὴ περιέβαλλον (9) ἀλλήλους καὶ στρατηγοὺς καὶ λοχαγοὺς δακρύοντες· καὶ εὐθὺς οἱ στρατιῶται φέρουσι λίθους καὶ ποιοῦσι κολωνὸν μέγαν. μετὰ ταῦτα οἱ Ἕλληνες ἀποπέμπουσι τὸν ἡγεμόνα δῶρα δόντες (10) αὐτῷ, ἵππον καὶ φιάλην ἀργυρᾶν καὶ σκευὴν Περσικὴν καὶ χρήματα· ὁ δὲ δείξας (11) αὐτοῖς κώμην, οὗ ἔδει σκηνεῖν, καὶ τὴν ὁδὸν ἣν πορεύσοιντο, ᾤχετο τῆς νυκτός.

NOTES. (1) Irregular aorist of ἔρχομαι (participle ἐλθών). (2) Future optative of ἄγω. (3) Future optative of ὁράω. (4) Governs the dative (from ἡγέομαι). (5) Second aorist of γίγνομαι. (6) Aorist of οἴομαι. (Note that verbs beginning with a diphthong take the temporal augment on the first vowel of the diphthong, αι becoming ῃ, and οι becoming ῳ—*e.g.*, αἰτέω, I ask, ᾔτησα; οἴχομαι, ᾠχόμην, as below ᾤχετο τῆς νυκτός.) (7) Present participle of ἔπειμι, come near. (8) and (9) Imperfect of παραβοηθέω and περιβάλλω respectively. (10) Aorist participle of δίδωμι. (11) Aorist participle of δείκνυμι.

Continued

1



7×7 to square inch

2

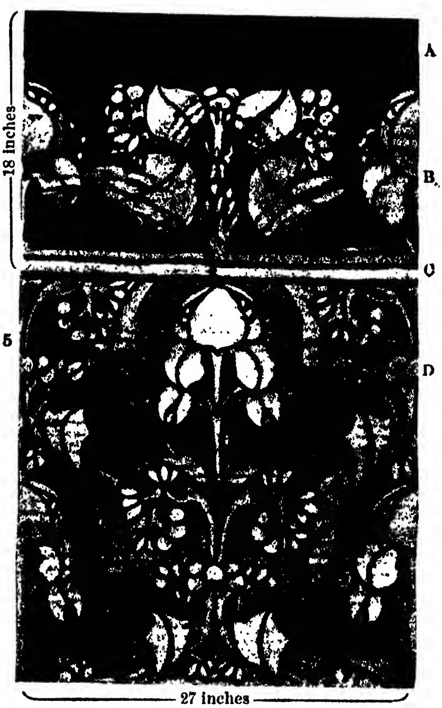
7×5 to square inch

1 and 2. Showing the effect of 3 when transferred to ruled paper 4. Method of breaking up colour masses and outline 5. Complete design with border

3

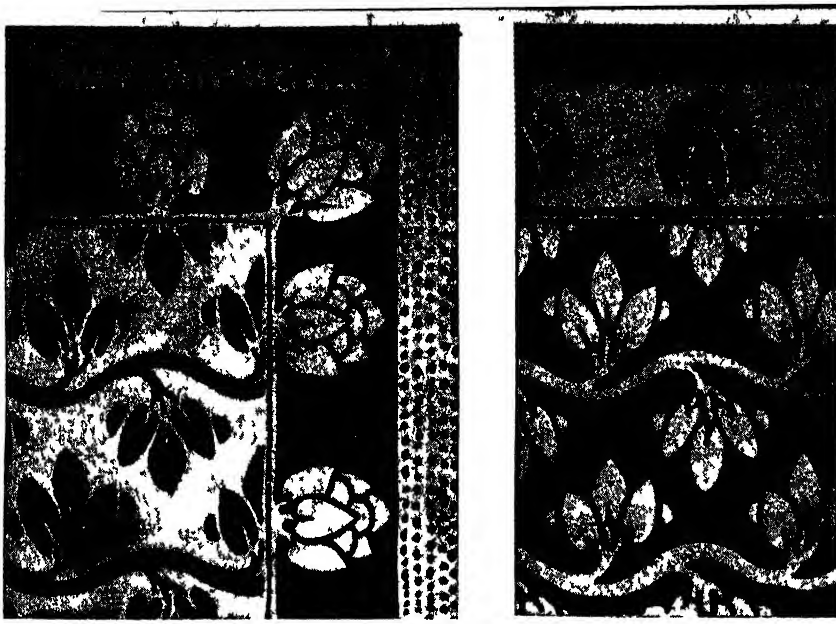
4

5

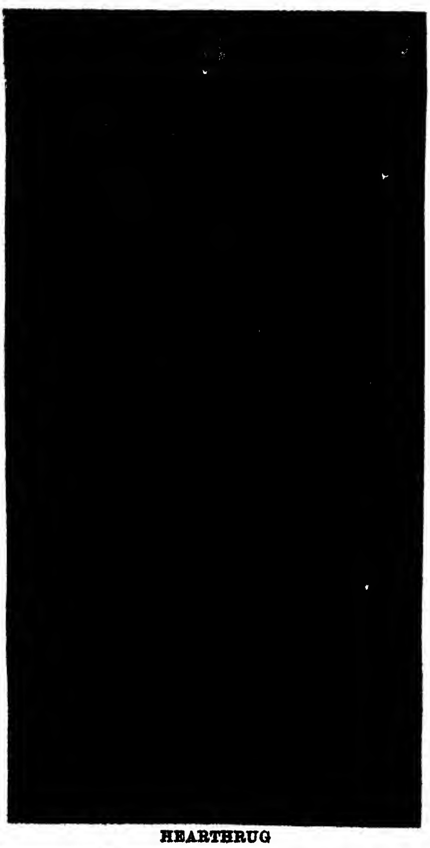


A. Outer guard B. Two-quarter border C. Inner guard D. Body or filling

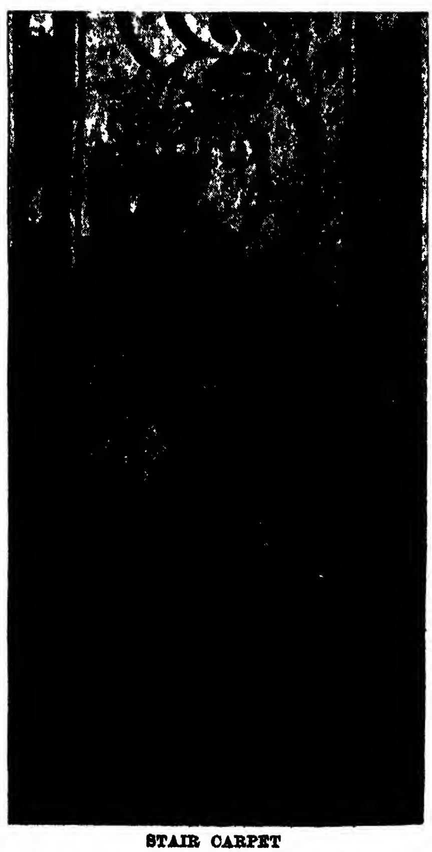
DESIGN FOR AXMINSTER CARPETS



TWO-COLOUR CARPET, SHOWING SAME PATTERN REVERSED



HEARTHRUG



STAIR CARPET

6. DESIGNS FOR REVERSING CARPETS

TEXTILE DESIGN

The Work of the Textile Designer. Making Patterns for Axminster, Brussels, and Wilton Carpets. Reversing Patterns

Continued from page 6277

By H. NAPPER

IN the following articles, containing practical knowledge necessary to the maker of patterns for all materials that require a pattern, it is intended to give, without being severely technical, just the amount required by the designer to make a design suitable for showing to a manufacturer; and also to serve the purpose of connecting the course on DESIGN with the practical articles of weaving in all its branches, which are included in this work [see TEXTILES, pages 2939, 3153, 3357, 5507].

Drawing for Textiles. The designer of to-day must, if he wish to be successful in his calling, be able to make patterns for all materials that require them, be they carpets, tapestries, silks, muslins, cretonnes, velvets, wallpapers, etc. He should also interest himself in furniture and carving for wood or stone, otherwise he will soon find that to limit his invention to one branch becomes irksome; but by taking up others he will return refreshed, and probably with ideas suggested by the change of thought.

The great difficulty in the way of the young designer is how to acquire this knowledge. Although we have schools for design, the practical side seems to be ignored. This is a great mistake. Moreover the ordinary productions of to-day are generally held in contempt. To give an instance. In looking at a collection of designs exhibited by young designers from any school of art it will be found invariably that they are only suitable for working in the most expensive cloths, and are costly in production because the same effect could be realised by the design being half its length, or by the reduction of the amount of warps and wefts.

The same remarks apply to wallpapers, where nearly all the designs could be produced only by block—that is, by hand—whereas this process of production represents only about one-tenth of the output by other processes used for wall-covering.

Market Requirements. The manufacturer depends for his ideas on the designer, and for his best work invariably buys from the designer who is working for himself—that is, for the general market, and not for any particular firm. There is generally a large staff of designers kept by the manufacturer; the majority of these are busy with the technical side—re-colouring, re-arranging, and adapting ideas, and the consideration of new effects in weaving and printing. If possible, the young man who can spare the time to go thoroughly into one branch, and feels inclined to specialise, should endeavour to get into a factory.

It is very necessary that the designer should keep himself in touch with what is being produced for the market. He should look around at the principal shops and take note of the class of goods, not with a view to copying the designs, but for the purpose of seeing what other people are doing and the kinds of cloths that are in demand, and also with the view of getting some notion of the scale of pattern; one year the fancy may be for large pattern, another for small, full or empty in material. These are all points the designer must take into consideration if he wish to be successful. Do not try to force your ideas on the manufacturer; he will come probably to your way of thinking in time.

There are so many hands for the design, when in the material, to go through, before reaching the ordinary buyer, that even the manufacturer cannot see his way to produce novelties without consulting others.

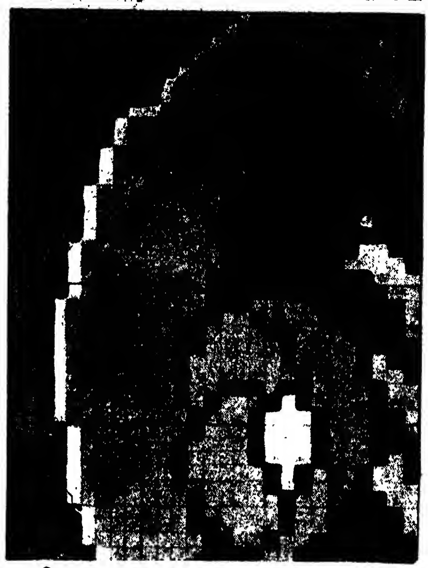
Axminster Carpets. Our object in taking the carpet as the first of this series of woven goods is because of its importance in the field of design, its variety, and also its difficulties. The fact of the carpet being looked at from above, unlike other woven fabrics, increases the difficulty of making a satisfactory pattern [see also TEXTILES, page 3357].

Axminster is the most interesting from the designer's standpoint, especially if he be a good colourist. In fact, it is not much use doing designs for it unless he is, for colour is its main feature, drawing counting for very little. This will be seen plainly by referring to the illustrations of a design transferred to the ruled or "point" paper [1, 2, and 3].

When the size of these blocks of colour which represent your outline—and these are the sizes generally used—is considered, it will be understood that delicacy of drawing, small detail, etc., would be unintelligible when woven, and get more so by constant repetition. The best method to start with Axminster is to find out the "pitch," or range of points used to the square inch by the manufacturer for whom the design is required. The variety is so great that it is imposible to give them all, but from five to seven to the inch are the pitches most generally used. Sketch the rough idea on this paper, say, in charcoal; experiment with the outline by filling in the squares along the line—this will enable you to get the "scale" required; it will also show, what is a necessity in all carpet work, how to get "roundness," or, in another word, "fatness," into the drawing. Having experimented on the ruled paper, and brought the idea into shape, the next question that will occur is the length of the pattern.

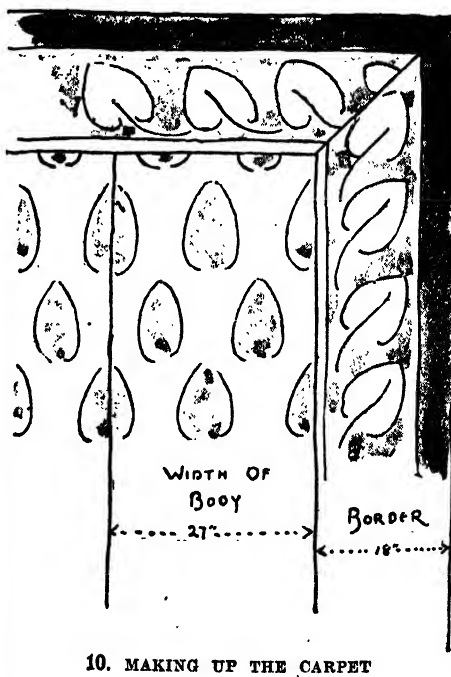
The width of the material and the drawing is always 27 in.; borders from 13 in., 18 in., or 22½ in. For length there is no fixed rule, but from 27 in. to 36 in. should be sufficient. Of

7. ROUGH DRAWING OF IDEA



8. DRAWING PUT ON RULED PAPER

9. METHOD OF PLANTING FILLING



10. MAKING UP THE CARPET

The method of making the ordinary Axminster, Brussels, and Wilton into the complete carpet

DESIGN FOR BRUSSELS CARPETS

course, if it be necessary to make a pattern which drops in the 27 in. or width of material, the designer can go up to 54 in. in length. These large sizes are not much used to-day, probably owing to a better understanding of design by the public and the improvement in design generally.

Manufacturers have seen that a large repeat does not give the most artistic result, or make a more serviceable carpet. The number of colours for Axminster is unlimited, but for all practical purposes thirty to forty will be found sufficient.

Preparing the Design. There are various methods of preparing carpet designs. The best, of course, is to put the drawing direct on to the ruled paper, thus making a practical drawing ready to go into the machine-room. It has its disadvantages, however; to the novice it would take a long time to cover, say, a square yard, keeping the colour exactly in these small squares, thinking at the same time of the drawing and colour. His time also would be in a great measure wasted, because colourists employed by the manufacturer would be able to do it in a third of the time, and see that the ranges of colour come within their collection.

Should it be decided to work it out this way, see that the design is complete in drawing before starting to paint. First put in the outlines, afterwards the ground, and then the filling in of the shapes. Be careful to use solid colour—that is, dry powdered colours mixed with gum. This is very necessary to cover over the squares, so that only the indentation made by the printing of the lines remains. No uneven or transparent effects should be seen, and every colour used in gradation or shading must keep a definite shape, which will be repeated exactly in the cloth.

Do not start colouring with primaries; break them well up, and mix various ranges of green, red, etc., by adding white or yellow, so that a perfect set is obtained, definite in tone, of each.

A splendid scheme can be made in this way of black, raw umber, burnt umber, and burnt sienna, broken with white only, giving the effect when massed together, of the richest reds, greens, and blues.

Making the Sketch. Some manufacturers buy small sketches made to scale, say one-fourth of the full size, or one-sixth, the latter preferred. This method is very unsatisfactory, both for the designer and manufacturer; it is impossible to give the right effect in such a small space of the detail, colouring, etc. But a great deal can be done in this way by repeating it roughly several times, and experimenting with border, etc., before drawing it full size.

The best method to make a satisfactory drawing is to start by considering the masses of colour [4]. After having decided on the length of pattern, take a piece of ordinary brown or tinted paper, and rule it out in square inches, with pencil, so that they can just be seen; then draw in either body colour or pastel. The latter is the better, as it can be taken out easily with bread; it also gives a certain amount of texture, which helps to realise the effect of the cloth.

Set the rough planning of flowers and leaves, and if the pattern is to repeat, say twice or three times in the 27 in., the squares will help to plan the colour arrangement without the trouble of tracing. Place the drawing as often as possible on the floor, and look at it from different points of view. Do not be afraid of making the design look hard, but endeavour to cultivate "definiteness," so that nothing is left to chance. The material being thick, with a rich pile, tends to soften both the colour and design when woven [5].

Axminster Borders. Borders for Axminster can be drawn in the same way as the filling or body [5]. They should be constantly put on the floor by the side of it to obtain the necessary contrast. Always make the border design larger or smaller than the main design, and get a good outer and inner guard, so that there is some plain colour near the floor and a definite line to separate it from the filling. A greater contrast can be made by having an entirely different scheme of colour, for the border in the usual make is woven separately from the filling.

There are other uses to which the same design can be applied—for staircase, landings, hearthrugs, etc.; but it is better not to consider these at first. The manufacturer usually has these arranged by the copyists or designers kept in the firm. There are other kinds of Axminster in which the borders are woven with a part of the filling; others with the complete design—that is, filling, borders, and corners woven together. The colours in these are generally limited, and, owing to the technicalities, the design also becomes limited, and can be produced only by designers with a complete knowledge of the working of the loom.

Brussels and Wilton Carpets. In preparing designs for Brussels or Wilton carpets, it is not necessary to make any difference in the appearance of the designs, for they are practically woven in the same way. The difference in effect is given to the cloth by what remains in a finished Brussels—the loop or thread, which fills the square in the design. This loop is cut through, making a tuft, thus making the Brussels into a Wilton; this gives a pile similar to an Axminster, but with a limited number of colours.

The sizes of Brussels—that is, width for borders, fillings, etc.—are precisely the same as Axminster; the great difference is the size of the points or loops. The point paper is ruled to about 85 points to the square inch, or 9 by 9½, nearly. Ordinary Axminster runs usually from 27 to 70. It will at once be seen that this gives a better chance for the expression, by drawing in the design.

Drawing, or the design, plays a very important part in Brussels, owing to the limited colour, which must be made up for in other ways by richness of material or by the careful disposition of the colours one against another. Sometimes by reversing them the same colours can be made to give a totally different effect. There is a new feature which can be introduced in this fabric—that is, by changing one colour (sometimes more) by *planting*. This we will endeavour to explain more fully. The top

surface of a Brussels is usually composed of five layers of worsted threads, which are called frames; these run the lengthway of the material, and are looped over wires to form the pile, the different colours required to form the pattern coming to the surface in a row of loops, each loop making the size of the points on the ruled paper.

Colour Arrangement for Brussels Carpets. The designer must not use more than these five decided colours. Now, if one of these be taken for outline purposes, there will be four only for ground, leaves, and flowers, or whatever material is used in the design. It follows, then, that any method by which any one of these colours can be changed gives an advantage to the designer. Care must be taken to start with this idea, for to do it satisfactorily entails an amount of thought and trouble not obvious to the ordinary buyer of carpets. These five colours running along the carpet are decided only in their number; one can change as many times as required so long as one keeps always to five colours in one line. This is called "planting" The designer can use it to give gradation if the design is planned for it; but the best method is to reserve it for giving bright effects in small parts of the pattern, so that the great error of making colours look like stripes is avoided. This will not be an easy matter at first, but after a while it will be found that in nearly all woven fabrics these technical difficulties often result in giving character to the work.

A good method is to make a strip of paper, with the range of colours marked in the line in which they are to be used, so that one can pass it up and down the design, and be certain the colours do not overlap. Another great point with regard to Brussels is that with the change of ground colour only the manufacturer can get an entirely different effect, in some cases making it look like a fresh design. This is a detail which should be always borne in mind, for, strange as it may seem, a design woven with a dark ground may not sell at all, but with a light ground may have an enormous success.

Reversing and Other Carpets. There is a great variety of other makes of carpet which cannot be explained by writing or illustration, owing to the complicated method of weaving. Tapestry carpet is one. This is a very common effect, usually woven in squares, and of a very cheap quality. In nearly every case, the cheaper the material, the more difficult it is to make a pleasing or satisfactory design outside the factory.

There are exceptions, however. The cheapest and best is what is generally called a "Roman" carpet, woven in squares of varying sizes, in two colours, giving, when reversed, the same pattern [6]. It is almost impossible to make a bad floor covering in this material, owing to its simplicity. The chief points to be noticed are that the filling must repeat with the border, both ways; that the detail must be always on the large or coarse side; and that the effect of it when repeated must be borne in mind so that a good effect on both sides is obtained. Sometimes a third colour is introduced. This serves to make a better or thicker material, and helps to give a bloom of colour, but obviously makes it more difficult, and generally destroys its use for reversing.

In illustration 6 the repeat of borders and filling and the method of making corners are roughly suggested, as well as the reversal of the grounds to make the border stand out distinct from the filling. The hearthrug contains the whole of its design in one quarter, but, by reversing exactly in the centre both ways, economy is obtained in design and weaving. This also applies to the stair carpet, in which the design, instead of reversing, is turned over. These methods of saving in production are more fully described in articles on woven fabrics.

There are at the present time a great many hand-made carpets to be seen. These, owing to their cost and primitive method of weaving, are generally used for special purposes. They contain no special technical limitations, such as repeats or limited colour. The designer, having a free hand, can carry his idea with variations all over the surface or change the colour in any way he may wish.

Examples of Carpet Design. In referring to illustrations of carpets it will be seen in the case of Axminster and Brussels [1, 2, and 8] that any small breakings or serrations of outline in the drawing become meaningless or impossible to express when placed upon the ruled paper. The hardness is, of course, slightly modified when the design is woven, owing to the tuft spreading a little. This is more noticeable in Axminster and Wilton.

The illustration of a Brussels [9] gives a piece of the complete carpet with border, with a detail of filling nearly full size. In the filling the method of planting in the full width of material is explained. Although it is marked in four different colours, it is possible to introduce changes again, and give a graduated effect of the same colour.

The method of planting the border is also shown. In this more contrast can be obtained, as it will not again repeat as in filling. Brussels and Axminster are made up to size of room by mitring the corner of the border and joining to strips of filling. If the length of filling repeat is long, some parts will have to be cut away and consequently wasted, in making up [10].

Hearthrugs and stair carpet are made in Brussels and Axminster with the border and filling complete, as in the illustration to reversing carpets [6].

We would advise the young designer to take every advantage of the collections of Indian and Persian carpets in the museums for purposes of study. Their perfect colour, invention, and planning make them for all time the ideal to be aimed at in a floor covering. There is always a market for designs of this class, not necessarily copies, but with the spirit, and the designer cannot do better in making a style for himself than learn from the great craftsmen of the past.

Continued

MINERAL WATERS

Principles and Process of Aerating Waters. Bottle and Syphon Filling. Making the Gas. Aerated Waters Made While the Customer Waits

Following WINES AND CIDERS from page 8266

By CLAYTON BEADLE and HENRY P. STEVENS

MINERAL waters may be divided into two classes—natural and artificial. The natural waters are taken from some spring or other source of supply, and consumed on the spot or bottled for delivery direct to various countries. Artificial waters are prepared by the addition of saline substances and impregnations with carbonic acid gas.

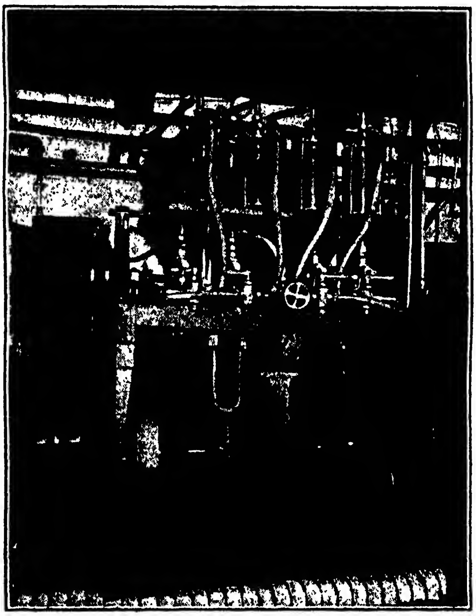
There are also waters which stand midway between these two classes—those which already contain some salts or other dissolved substances having medicinal or other qualities, and which are fortified by the addition of further salts or carbonic acid gas.

Principles of Manufacture. Water such as is got by artesian wells from the chalk below the green sand formation in the London Basin is perhaps the best adapted for the manufacture of "minerals." It is soft, slightly alkaline, and very free from organic impurities. The analysis of such a London water made by a well-known expert showed only 0·0004 parts per 100,000 of organic ammonia, 5° of hardness, and six bacteria per cubic centimetre. Such water is practically sterile.

Aeration, as it is called, consists in saturating water under pressure with carbonic acid gas. Water at ordinary temperature, say 60° F., absorbs about its own weight of this gas (if cold, it absorbs more; if warm, less). All bottling is done at ordinary temperatures with cold water. If the pressure on the gas be doubled, the volume is approximately halved; if doubled again, the volume is again halved; but no matter what the pressure, one pint of cold water (60° F.) absorbs one pint of the gas. If, then, we double the atmospheric pressure by applying 15 lb. per square inch, we get twice the amount of gas into the water. On releasing the pressure, the excess of gas escapes into the air. As ordinary bottling is done at from 60 lb. to 100 lb. per square inch, a large amount of the gas is absorbed by the liquid.

The principles of manufacture, which we will describe in some detail, are chiefly in accordance with those adopted by Camwal, Limited, where the work is conducted under scientific supervision.

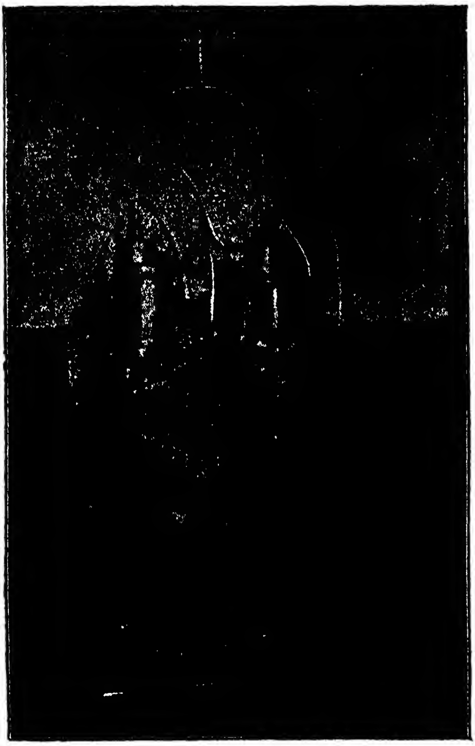
Mixing the Gas. Carbonic acid gas used in these works is a natural gas obtained from Germany, where it is compressed as a liquid in steel cylinders under a pressure of 800 lb. per square inch. These cylinders are stood on end, and connected up, six at a time, with a receiver resembling a miniature gas holder. By discharging into this holder, the gas is obtained under a few inches of water pressure. The rate of evaporation from the cylinder causes a portion of the liquid to freeze to a solid, which makes itself evident by frost on the outside. The cylinders are then removed and others attached. The warmth of the air, or of warm water, converts the solid gas back into a liquid, and the cylinders are again placed in contact with the receiver, and the gas completely absorbed by the aid of a warm water jacket.



1. AERATING MACHINE

The gas from the receiver then passes through pipes to the aerating machine. Here it is washed as a final precaution, by bubbling through glass cylinders containing water. As the gas contains 99·4 per cent. of pure carbon dioxide, this precaution does not appear to be necessary. The gas then passes through three-way cocks, where it meets with water. These cocks can be so regulated as to supply any proportion of water and carbonic acid gas. The water, the composition of which has already been referred to, is pumped from the deep well into a tank, where, for the manufacture of soda-water, it is rendered alkaline by the addition of pure carbonate of soda. The water has a natural temperature of 56° F. Each mixing tank holds exactly 200 gallons. Bicarbonate of soda is added by means of a suspended filtering bag through which the water flows and dissolves it into the tank. The chemist checks every mixing by analysis, as a check to the weighings, the figures of which are carefully recorded.

The alkaline water then passes through silver-plated connections and tin pipes to the various aerating machines above described. It first enters a small feed tank with a glass front, provided with a ball-cock, and then goes to the three-way taps, from whence the mixture of gas and water passes into the carbonating chamber. This machine is made of gun-metal, and is lined inside with tin, ¼ in. thick. With a large machine, the cylinder has a capacity of 80 gallons, and is worked under a pressure of 180 lb. per square inch, the cylinder being half full of water and half full of gas.



2. SYPHON-FILLING MACHINE

Agitation is promoted by a longitudinal shaft provided with triangular perforated paddles, and revolving at 60 to 80 revolutions per minute. The gas and water are pumped into the cylinder by four pumps and four sets of pipes, pairs of which can be worked independently [1].

The water which has thus been ærated thence passes to the filling machine at a pressure of about 180 lb. if required for filling syphons, and 120 lb. for filling bottles and "plain goods"—that is, not containing syrup or sugar—and about 90 lb. for sweet drinks. The actual pressure in the syphons or bottles is about half that at which the water is forced into the vessel. The biggest carbonating cylinder will fill about 1.800 30-oz. syphons per hour.

Filling Aerated Water Bottles. In filling bottles fitted with glass marbles as stoppers the marble is forced into the neck of the bottle by the pressure of the gas inside the bottle.

With screw-stoppered bottles, the stopper is screwed loosely into the neck of the empty bottle; it is then placed under the machine, which removes the stopper, fills the bottle, and screws the stopper in firmly.

Bottles fitted with ordinary corks are held in position by the machine and the cork is placed in a holder. When the machine is started working, the bottle is filled, the cork dropped into position, and rammed into the neck by means of a small ram. By the thrust of an arm, the bottle is thrown out of position and pushed down a chute. To avoid "cork dust," the corks are previously washed in water, but as an extra precaution, the ram delivers a spray of aerated water, so as to further cleanse the cork at the moment of insertion. In all the machines, the aerated water is forced into bottles by the pressure of the carbonating cylinder. If syrup is to be added, as in the case of lemonade, ginger ale, etc., it is admitted to small pumps from the tanks above, which deliver at each stroke the requisite quantity to the bottle, which is made up at the same time with the proper proportion of aerated water. All the modern filling machines are fitted with a syrup and aerated water saving device. By this means, no water or syrup can flow unless the bottle to be filled is fixed in its place. In this way, a great deal of unnecessary waste is saved.

When the aerated water is forced into the bottles the air in the bottle is driven out. This is called "snifting." In the case of syphons, the "snifting" gases are collected and used again, as they consist of pure carbon dioxide left from the last filling, but in the case of bottles they are allowed to escape, as they contain a large percentage of ordinary air.

Syphons. Syphons are filled through the spout. They are fixed so that the spout is pressed against the pipe through which the water is to be admitted. The lever is then pressed down, by means of a small arm actuated by means of a pedal, and the soda-water is forced in so that the pressure in the syphon is equal to that at which the water is entering. The water valve is then closed automatically, and the "snift" valve is opened to allow the gas inside to escape. The "snift" valve then closes again, the water valve is opened, and the syphon is filled up [2]. The gas in the best soda-water syphon contains about 0·6 per cent. of air, the rest carbonic acid. There must not be more than 2 per cent. of air, or the syphon cannot be properly emptied. After the syphons have been filled the tops are burnished by means of a revolving calico disc, and then the body of the syphon is washed and the labels stuck on. The syphon tops of the Camwal Co. are made of pure tin, with only sufficient antimony and bismuth to give the requisite hardness. Some are silver-plated, but this is merely to give them a better appearance, as the tin is absolutely safe.

There are two sorts of syphon tops—*viz.*, those with the long lever, and those with the short ones [4]. With the long lever tops, the lever is raised to deliver the liquid, while with the short valve, the valve is depressed. The former work against a spring, which must be strong enough to prevent leakage; but in the latter, the pressure forces the valve against its rubber setting, and so makes its own joint. Opinions differ as to which is the better, but the public seem to like the long lever, as it gives better control when pressing. The sudden spirt when starting a new syphon is due to the valve sticking and coming away suddenly. The Idris

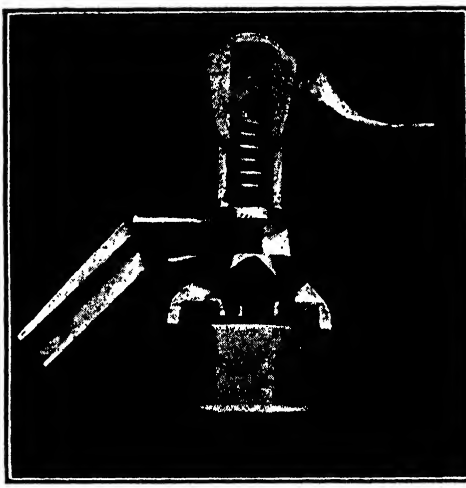
3. SYRUP COOLERS AND FILTERS

Company make a china plug and nozzle fitted inside, so that none of the liquid comes in contact with the metal top. Metal contamination results from the use of unsuitable metal tops.

The Preparation of Syrups. The best crystallised cane sugar is boiled in a steam-jacketed copper. The strength of the syrup is made up to from 40° to 50° Tw., 2 cwt. of sugar being used at each boiling. The syrup is then run into a cooler [3], and fru t acid essences are added to give it the necessary flavours. The mixture is then filtered through a bag to the tank, whence it is led to the various filling machines.

Soda-water varies in strength between 5 gr. and 30 gr. of bicarbonate per pint. The British Pharmacopœia formerly gave soda-water at 30 gr. per pint. Prosecutions are usually instituted where the amount is under 5 gr. per pint. The strength is largely a matter of taste. The amount in the case of lithia is 10 gr., according to the British Pharmacopœia, 1885. Potash is 5 gr. to 15 gr. Seltzer water, properly prepared, is a mixture of sodium bicarbonate, sodium chloride, and magnesia, but, as generally sold, means nothing. There are, in addition, aerated distilled water and carbonated water.

Preparation of Ginger-beer. The water is first boiled in a steam-jacketed copper, and is then passed into a mash-tun, where it is mixed with crushed Jamaica ginger. The whole is then run into a settling tank where fruit acids are added, and the liquid, after reduction to proper temperature, is drawn off into the fermenting vat, where it is mixed with sugar (1 lb. per gallon), and allowed to ferment for twelve hours. It is then run off and filled into stone bottles in special filling machines, after which it is stored for about a fortnight, during which time the proper aeration is promoted as a result of the fermentation which takes place. Ginger-beer so prepared contains from 0·6 per cent. to 1·4 per cent. of alcohol. The extreme legal limit is 3 per cent., but manufacturers are warned if 2 per cent. is exceeded.



4. CAMWAL SYPHON TOP

Preparation of Carbonic Acid Gas. Many firms still make their own carbonic acid gas by adding sulphuric acid to whiting or sodium bicarbonate. To a large cylindrical tank, half full of water, a charge of 2 cwt. of bicarbonate is added. Sulphuric acid is then run into it from a reservoir situated at the top, and carbonic acid gas, so called, is drawn off by a pump to the aerating machine. On its passage it is purified free from nitrates by passing through alkaline potassium permanganate solution, which also removes any spray of sulphuric acid wh ch might be carried over mechanically. This method of producing carbon dioxide gives trouble on account of the amount of air it is liable to contain, hence the use of pure natural gas.

Large quantities of sulphuric acid, in jars, surrounded with whiting, are shipped to India and the Colonies for the production of carbon dioxide to be used in the manufacture of aerated waters. If these jars should break during shipment the acid is absorbed by merely converting the whiting into plaster of Paris. The empty jars are cleansed, refilled with Indian pickles, and shipped back to this country. Carbon dioxide is also produced during the process of fermentation in breweries, where it is compressed into cylinders and sold to makers of mineral waters.

Perhaps the most advanced method of producing the gas is from coke, according to Stead's and Leslie's patents. A very ingenious process (Stead's patent) has been installed by the Idris Company, whereby gas of the highest degree of purity is produced. The process consists in the main as follows: The products of combustion of special coal or coke are forced, under pressure of 20 lb. to 30 lb. per square inch, into carbonate of potash solution, which is thereby converted into bicarbonate, after which it is heated with the evolution of pure carbon dioxide, and the re-formation of ordinary carbonate.

Domestic and Automatic Aeration. Retailers of mineral waters can now prepare their own if they so choose. Attempts have been made from time to time to introduce a machine for this purpose. From the description already given of the manufacture of "minerals" on a large scale, the principle of the ingenious "multum in parvo" machine known as the "Consol" (British Automatic Aerators, Ltd.) [6] will be grasped readily.

It enables the retailer to deliver at the point of consumption an aerated water of good quality, freshly made for each customer, and also enables him to dispense with the cumbrous boxes of bottles formerly needed for his business.

This machine occupies a space only slightly exceeding 1 sq. ft., and can be fitted to any bar or shop counter. In addition to ordinary aerated water, it can be made to produce soda, potash, lithia, lemonade, ginger-beer, ginger-ale, etc., by adding the necessary amount of soluble constituents, according to well-known recipes.

It differs from other "draught apparatus," such as soda fountains, various forms of draught arms, etc., in that it manufactures each drink as required, whereas ordinary apparatus has to draw from a previously manufactured store, which deteriorates on keeping. The entire operation is performed by a right and left movement of the handle, which occupies a period of not more than five seconds, so that it is possible to draw on draught the equivalent of 60 dozen bottles per hour.

A filter should always be fitted where any doubt exists as to the purity of the water, and in all cases where it is desired to produce the highest class of "minerals." Suitable germ-proof filters have been designed for special use with the aerator, all that is necessary being to introduce the filter at any convenient point in the water supply.

Aerated Water in Open Jugs. It is claimed by some that aeration on a small scale produces a different result to aeration in bulk. It is

said that it so saturates the water with the gas (CO_2), that it is actually held in solution, and not given off in a violent eruption upon the removal of outside pressure. The experiment described below may be taken as showing that water aerated in bulk does *not* retain the gas for any length of time after opening the bottles We cannot undertake to sift the evidence on this point, and as "minerals" from bottles and syphons, especially the latter, are consumed almost immediately after opening, we need hardly concern ourselves with it Nevertheless, domestic aeration makes it possible for aerated water to be served in open jugs, without detriment to its sparkling qualities, a point which should prove of decided gain to the public

The following simple experiment illustrates this A tumbler of aerated water is drawn from the small hand machine, and a similar tumbler is filled from a bottle or syphon supplied from an ordinary mineral water factory. The two are left side by side for half an hour or longer, each is then gently stirred with a thin rod or knitting needle. That from the bottle will be comparatively flat, whereas that from the small machine will "bead" round the rod and effervesce freely

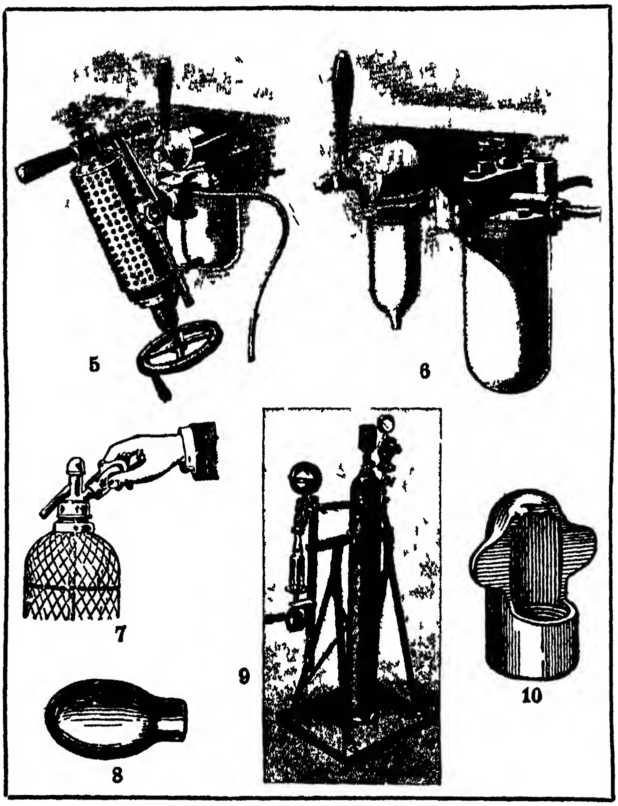
Although the aerator has been designed primarily to make and supply aerated water straight into the glass, yet both screw - stoppered and corked bottles can be easily and rapidly filled Where it is desired to bottle under pressure, an attachment is added for filling any description of bottle, particularly suited for ball stoppered bottles (known in the trade as cod bottles). This is attached to the aerator by removing the delivery vessel. The illustration [5] shows the attachment.

Another Simple Machine for Bottling Only. Another machine, worked somewhat differently, is shown in 9. In this case the bottles have first to be filled with the water to be aerated. They are then clamped on to the attachment communicating with a tin ball full of gas under pressure By pulling up the lever, the bottle is inverted, causing the water to flow into the ball, where, by the aid of shaking, it becomes aerated. The lever is then lowered, so that the bottle is the right way up, when the aerated water finds its way back into the bottle. The machine is of cheaper construction, but slower in its action than the "Consol," and it will not deliver direct into the glass. It appears to answer its purpose.

Sparklet Aeration. We will conclude our account of mineral waters with a short description of the Sparklet syphon (Aerators, Ltd.). By means of this ingenious system anybody can make at any time and in any place as much freshly aerated water as desired The principle of the system consists in the sale of carbonic acid gas strongly compressed in small steel bulbs which are fitted on to the syphon and pierced by turning a screw, which allows the gas to escape and saturate the water with which the syphon is previously filled The bulb containing the carbonic acid gas, and the bulb - holder into which it is slipped neck downwards, are shown in 8 and 10 The vase of the syphon, the upper part of which is shown in 7, is filled with water to a red mark near the top, the glass tube is inserted, and the head screwed down without employing undue force. The bulb - holder, containing the bulb, is held with the thumb on the bulb so that the neck of the latter protrudes slightly below the bottom of the holder The protruding neck of the bulb is now inserted centrally into the hollow formed by a washer and gently screwed down Inside this hollow and projecting outward is a pin, which enters the end of the bulb and pierces it, in this way admitting the gas from the bulb into the syphon. The bulb holder is screwed down gradually, shaking the syphon well from time to time and continuing alternate screwing and shaking until no more bubbles of gas are given off. The syphon is now ready for use, but the aeration is improved if the syphon be allowed to stand a few minutes before drawing off the contents.

The glass vases are covered with a metal wire, and are tested to a pressure of 220 lb. per square inch

Either plain water alone can be aerated or small quantities of soda, potash, lithia, or fruit crystals may be previously added in the form of "sparkloids," thus producing soda, potash, or lithia water, or other effervescing drinks of various descriptions.



DOMESTIC AND AUTOMATIC AERATION
5 Consol aerator for bottles 6 Consol aerator for counter supply 7 Sparklet syphon top 8 Sparklet gas bulb 9 Mineral water bottle filler (H Toomer & Co, Ltd) 10 Sparklet bulb holder

MINERAL WATERS *concluded; followed by* TEA, COFFEE, AND COCOA.

HAND & MACHINE-MADE PAPERS

Plant and Processes in Making Paper by Hand and by Machine. Uses of Wood Pulp. Representative Papers

continued from page 6285

By CLAYTON BEADLE and HENRY P. STEVENS

THE process of making paper by hand is the same to-day in principle as it was long before the Christian Era. The Chinese and Aztecs, independently and without knowledge of one another's craft, employed a rough frame covered with hair or fibres through which the water drained, leaving a wet film of paper on the surface to be transferred for drying. To-day not more than 1 per cent. of the output of this country is made by hand, the rest being made by machinery. There is none made by hand in the United States and Canada, but considerable quantities on the Continent.

All hand-made papers in this country and on the Continent are made from cotton and linen rags and hemp. In the East they are made from the native fibres. In a "hand mill," as it is called, the preliminary processes of dusting, hand sorting, boiling, bleaching, "breaking-in," and beating are conducted in a similar manner to the treatment of rags in a machine mill, as already described, only, of course, on a smaller scale. As only the best papers are made by hand, the best rags have to be selected, and every care has to be exercised that they are free from dirt. The beating engines are nearly always of the "Hollander" type and of small capacity, the most convenient sizes being such as will take 105 lb. to 250 lb. dry weight of rags.

Tub-sizing. The general principles of tub sizing paper are more or less common both to machine and hand made papers but hand-made papers —at least all those worthy of the name—are always tub sized with gelatin to make them ink bearing. The tub-sizing process is, perhaps, the most difficult branch of paper-making to master in all its multifarious details.

Waterleaf, or unsized paper, in addition to being porous, has little or no wearing qualities, and is deficient in strength. It lacks what is appropriately but vulgarly described as "guts." Up to the waterleaf stage, for ninety-nine purposes out of a hundred such paper would be useless. The gelatin supplies it with additional strength, its original strength is very often more than doubled, it makes it inkproof, gives it firmness, "rattle," "feel," and such desirable qualities. In the trade language, it puts guts into it. There is as much difference between waterleaf and sized paper as there is between glazed and unglazed earthenware.

The Sizing Solution. The size solution can be made by extracting wet hide pieces, etc., with warm water—a complex industry in itself, but one which up to recently the paper-maker had to conduct on his own premises; now frequently he buys sheets of ready-made gelatin or glue, according to his requirements.

In the latter case the sheets of gelatin are soaked in water for twelve hours, the cold water being then run off, and hot water introduced to dissolve the gelatin. Alum is almost universally added as a preservative and means of control. This is then reduced to the necessary consistency or strengh with or without the addition of soap. The solution is introduced into the sizing trough [34], which, at one time, was a mere tub—hence the name of the process—but now consists of a vat heated either by steam coils at the bottom or by a jacket, and is preferably made of copper. The temperature is maintained at 100° F. to 120° F.

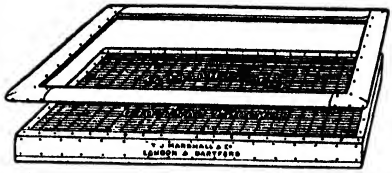
The "sizeman" has to control the quantity of gelatin entering the paper. This object is to get the best sizing effect with the least quantity of gelatin. The addition of small quantities of alum has the effect of thickening the size, and so reducing its penetrating qualities, although, curiously enough, if too much alum is added, the size is said to be killed; it becomes thin, and, in consequence, will readily penetrate the paper. This, however, is an effect to be carefully avoided. Alum, nevertheless, affords the chief means of controlling the quantity of gelatin that enters the paper. Increase of temperature means decreased viscosity and increased penetration. The temperature may be varied only within certain limits.

The soap in the size—which, by the way, must be of special composition—renders it opaque, somewhat improves its colour, and imparts to the paper special qualities, the chief of which, perhaps, is in reendering the paper more easily cut under a guillotine. If no soap were used the knife might go through with a bang. Soap also helps the glazing and surfacing under the action of the calender rolls, to which reference will be made later. Alum, if added to the chest, causes the waterleaf to be less easily penetrated by the size. As the penetration takes time, the immersion in the sizing vat must be prolonged to complete the penetration to the centre—that is, if hard sizing is required. The squeezing after immersion removes a part of what has penetrated according to the pressure applied, but assists in the removal of the air from the centre, which air is replaced by gelatin. If the sheets come gradually into the solution between perforated felts running nearly horizontal in a shallow trough, the saturation takes

31. SINGLE VAT

place from the under side, slowly driving the air to the top side. This is the modern mode of sizing hand-made sheets or cut sheets of machine-made paper. The sheets, fanned out in bunches in three rows abreast, are placed on a table, whence they are fed on to a travelling felt, which slowly carries them through the size. The upper felt holds the paper down. The paper, rising out of the vat thoroughly saturated, passes between the squeezing rolls, from which it is removed for drying.

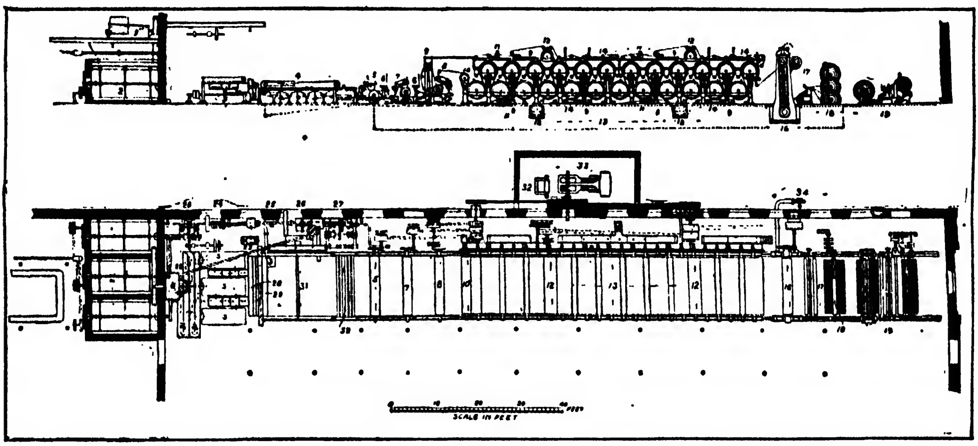
Drying. The proper drying of the sized sheet is no easy task. It is here that the paper-maker frequently fails. The sheets are removed to a loft and hung in bunches over strings or laths until air-dry; the arrangement is somewhat like that used for drying the hand-made waterleaf, copper rollers, should rise vertically upwards and pass through the "nip" of the bronze rolls. This keeps the inside of the paper air-locked, and so retards penetration.



32. LAID HAND MOULD AND DECKLE

Making Hand-made Paper. The bleached and beaten stuff, containing, as a rule, no size or mineral, but starch, and sometimes colouring matter, is now emptied into the stuff chest. From this it is raised by lifting buckets to a small box at the head of the vat, with overflow back to chest. This gives a constant head of stuff for supply to the vat.

The vat [31] in which the hand made paper is produced, may be of wood or stone, but is usually of iron, lead lined and rectangular in shape, and smaller at the bottom than at the top.

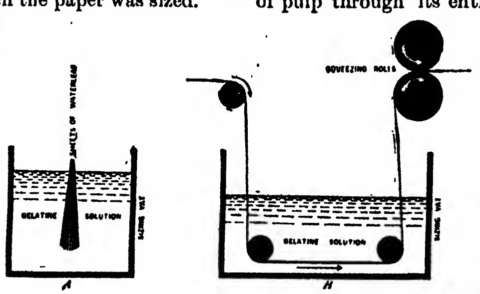


33. PLAN AND ELEVATION OF A FAST-RUNNING NEWS MACHINE (James Milne & Son, Ltd.)

1. Beating engine 2. Stuff chests 3. Strainers 4. Wire 102 in. wide 5. Couch rolls 6. Gangway 7. 1st press rolls 8. 2nd press rolls 9. Felt stretch 10. Leading cylinder 11. Auto guide 12. Felt dryer 13. Drying cylinders 14 Auto stretch 15. Hand guide 16. Calenders 17. Slitters 18. Reels 19. Reeling and slitting machine 20. Stuff pumps 21. Sand tables 22. Mixing box 23. Shake 24. Back water pumps 25. Backshaft steam engine 26. Auxiliary pump 27. Vacuum pumps 28. Breast box 29. Breast roll 30. Tube roll 31. Vacuum boxes 32. Speed cones 33. Coupled steam engine 34. Fan for cold blast

except that the temperature is kept down. To produce a perfect result it is imperative that the temperature should be below that of the melting point of the jelly with which the paper was sized.

Tub-sizing Machine Papers. With machine-made papers the sizing vat is either a continuation of the paper machine itself, coming next to the drying cylinders, or the operation is conducted in a different room by attaching a reel of waterleaf paper removed from the machine to the sizing vat. The reel is unwound and passed through the vat containing the size, then through a pair of bronze squeezing rolls, which remove any surplus, after which the sized paper is usually re-reeled. If only surface sizing is required, the web should dip vertically downwards into the vat [34B], and after passing round two immersed wooden or



34. TUB-SIZING MACHINERY

In it is a "hog," so called from its turning up and disturbing function, revolving horizontally near the bottom to secure uniformity and consistency of pulp through its entire depth in the vat. The heating arrangements by steam, as well as the regulation of flow to the vat, are under easy control by the vatman, who stands against the middle of the front side of the vat, a leaning board being provided for his support. The strainer is on his right hand, and just in front of him, resting on the ends of the vat, lies the *bridge*.

The bridge, made of wood, has several uses; upon its top side half round brass strips enable the mould to pass easily and rapidly to and fro. It also forms a rest for the mould, ready to the vatman's hand, and, further, being provided with a curved support at its lower end called an

"ass," the mould with the freshly made sheet upon it, rests and drains until taken away by the "coucher"

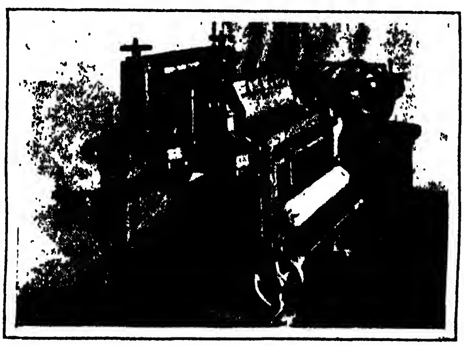
The mould [32] next occupies our attention. There are two to each vat, and each is a mahogany frame about 1½ in. deep, as light, true, and rigid as possible, and of the size of the required sheet of paper. Transverse brass wires passing through and over light wooden bars help to keep the frame taut, and form a support for the top wire which covers its entire surface. The covering wire determines the markings of the sheet of paper, and, as with machine-made paper, are described as "laid" [32] or "wove." These are called "face" wires and upon them the device, name, date, etc., are fixed by fine wire, and this forms the watermark. Fitted to each mould is the "deckle," also a light mahogany frame, having a rebated edge which accurately fits over the mould frame and forms a raised edge above the face wire all the way round. Only one deckle is in use to a pair of moulds, and it is in the hands of the vatman practically all the time.

35. SET OF STUFF CHESTS

The "coucher," or the man who turns off the sheet of paper from the mould, stands at the bottom end of the vat and opposite to the vatman, and the "layer," usually a lad in his apprenticeship, is still further away from the vat and practically in line with the vatman. These three are a "vat's crew."

36. LECHLER'S SPRAY

The Vathouse. The vatman, taking a mould with its deckle in position, dips it into the pulp which, flowing over the deckle edges, forms a regular stratum on the upper or wired face of the mould. As the mould is lifted clear of the pulp a partial vacuum draws the stratum of pulp on to the wire, and then with an individuality separate and distinct from all other vatmen he weaves and interlaces the fibres by shaking the mould and contents transversely and longitudinally, and finally by a fillip throws the surplus water from off the mould; and within the deckle edges lies the sheet or sheets of paper. There may be two, three or even four sheets on one mould, but usually only one. It is just here that the secret of "hand mades" lies. No mechanical device can, or will, adapt itself to changing conditions and perform similar and equal work.



37. CUTTER

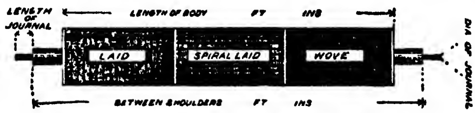
The Coucher. Meanwhile the coucher takes the resting mould with its paper and turns it edge downwards on to a pile of soft felts, slightly larger than the mould itself. With a rolling motion, also peculiar to each man, the mould is pressed face downwards, and, as it is again lifted, it leaves the paper on the felt. The mould is returned to the bridge, another felt is laid over on the paper just deposited, and then the operation of couching a second is repeated. This goes on, paper and felt alternately, until a "post"—that is, a certain number of felts—are piled upon an equal number of layers of paper, the pile supported upon an elm plank, which, with its load, is placed under a pressure of 200 tons between head and table of an hydraulic press.

The effect is that enough moisture has been removed from paper and felt as will enable the sheets to be taken safely from the felts, and yet not to crush the paper. Again the post retraces its steps, this time to the layer, who takes each sheet of paper with both hands, and evenly and exactly places them one upon each other, and with his right hand throws the felt for the coucher to use. In this way with perfect regularity of time and motion, the sheets of paper are made, couched, and laid, and instead of a post, the wet sheets of paper are laid together and called a *pack*. The day's work, however, is reckoned by posts—a certain number of posts corresponding to a given size and sort is mutually agreed upon between the trade and the employer.

The pack, as we now describe the sheets of paper in bulk, is pressed between zinc plates, and then taken to pack sorting-room. Here, women and girls sort again every single sheet, keeping each pack intact, and these are now sent to the drying loft.

Drying Lofts. The drying of hand-made papers is usually done on "cowhair lines," which are found to be cleanly, and leave no stain—an important consideration. The "dry workers" take the packs, and with these rows of cowhair lines overhead, pick up several sheets of paper with the left hand, and, holding a wooden tee in the right hand, catch the suspended sheets as nearly as possible in the middle of their lengths, and raising them by the tee, pass up one end over the hair line. Two men work side by side, and these lines are in frames holding 15 to 25 lines, long enough to take from six to eight widths of paper. When filled as described, the frames are lifted up on the shoulders of the dry workers, who stand on ladders, and the vertical posts, four to each frame or "room," as it is called, are fitted with movable pegs, which support the weight and enable tier above tier to be fixed.

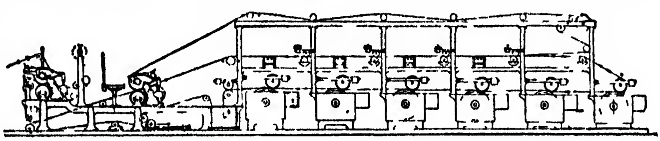
The lofts are usually high and narrow; two rooms in width are rarely exceeded, but in length any convenient number. When filled, thousands of sheets hang in these lofts, tier above tier regularly in rows and even in line. The heat for drying is obtained from steam pipes on the floor, ventilation by "louvre" windows and other methods. Under the roof, all lofts should be ceiled, and wooden partitions effectively divide lofts. When dried, the paper is taken down from the lines, and it is called "waterleaf"—that is, it is absorbent, really a blotting paper—and before it can be used for writing and printing it must be sized.



38. MARSHALL'S DANDY ROLL

When successfully sized, the sheet of paper may be written on and erased, written over and erased again, still opaque and resisting the ink to the last thread. The sizing process has already been described. The hand-made sheet, after tub sizing, is dried on lines in the same manner as the waterleaf, but a continuous web is treated differently.

Skeleton Drum and Festoon Driers. For the production of a continuous web the drying is effected by passing it over skeleton drums in the centre of which small fans revolve at different speeds according to the condition of the paper. These cause the cool air to impinge on the surface and accelerate the drying. A long dryer may be sufficient to accommodate three-quarters of a mile of continuous web. Perhaps the more modern method is to dry paper by means of a festoon machine. The latter permits free shrinkage of the paper, and does not cause a "quiver," as with the skeleton drums.

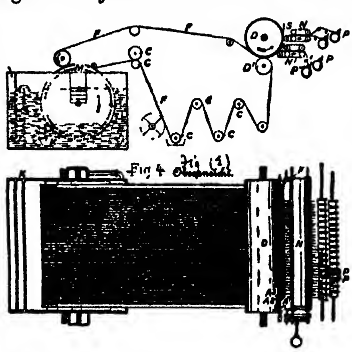


39. ELEVATION OF TRIPLEX CARDBOARD MACHINE
(James Milne & Son, Ltd)

When the sized paper is dried it passes over a cutter. If necessary, it is slit longitudinally with circular knives, and then cut transversely into the sizes required by the wholesale stationer.

Single-sheet Sizing of Machine-made Papers. To obtain the best possible results with machine-made papers the waterleaf can be cut into sheets before immersion in the sizing trough, when it is treated by one or other of the methods employed for sizing and drying hand-made papers.

An excellent method of providing heat for single-sheet drying is by turning the steam boiler economiser into an air heater. This is done either by entirely replacing the ordinary economiser or by putting down a supplementary air-heater. Hot air so produced can be used for drying either waterleaf or sized sheets.



40. MACHINE FOR MAKING PAPER YARN BY TÜRK'S PROCESS

Paper Machine. Up to 100 years ago all paper was made by hand. The paper machine was the invention of a Frenchman, Louis Robert, who brought his invention to England, where, with the assistance of Henry and Sealey Fourdrinier, the help afforded by Gamble and Didot, and the ingenuity of Bryan Donkin, the invention was ultimately made a success. We have already traced the progress of the beaten stuff to the stuff chests. These are large reservoirs made of wood or metal, and provided with mechanical agitators [35].

The pulp from the stuff chest is raised by means of a stuff pump to a constant head, whence it is delivered by an automatic control arrangement to a mixing-box, where it is diluted with water, and, if necessary, heated by steam. The stuff in the chest contains, say, 5 per cent. fibre and 95 per cent. water. After passing the mixing-box, it contains, say, from ½ per cent. to 1 per cent. fibre and the rest water. It then flows over a sand table, a wide trough fitted with numerous cross-pieces of wood at intervals of about 3 in.; in between these cross-pieces any heavy impurities, such as sand, grit, particles of buttons, etc., settle.

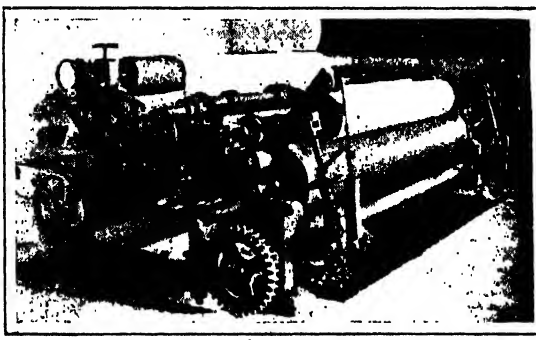
The Strainer. The stuff then passes to the "knotters" or "strainers." These are of different forms. A common form is the bellows strainer. A substantial plate of brass or gunmetal perforated with numerous very narrow parallel slots, and having sides to it — in old types provided with lugs — is fastened to an outer frame of iron, the bottom of which consists of a movable plate attached to the frame by an indiarubber connection. The plate, when in operation, lies horizontally. The movable plate forming the bellows is actuated by an eccentric on a shaft, or by a toggle joint, which gives to it a very rapid up-and-down motion or quiver, causing the stuff in the "knotter" to vibrate and to draw at lightning speed in and out of the slots. The principle is this. All fibres tend to point in the direction of the current. As the current is promoted in and out of the slots, the fibres pass through end on, whereas all knots, untreated stuff, and other particles too large for the slots are retained on the surface of the "knotter." The "retained knotted stuff," as it is called, was formerly removed by hand by scooping it out from time to time, but is now automatically removed by an arrangement which scrapes the surface at regular intervals. It would be impossible without such contrivances to make clean paper. The progress of the stuff from start to finish is shown in 38.

The stuff next passes to the breast-box of the machine, where it overflows a lip on to an endless wire band, which latter, in addition to travelling forward at from 40 ft. to 500 ft. per minute according to circumstances, receives a lateral shake to promote the felting of the fibres. The wire cloth is supported on a number of tube rolls, which are actuated by the wire passing over them. The formation of foam often gives much trouble on the paper machine, detached particles come away and spoil quantities of paper. Many remedies, both mechanical and chemical,

have been suggested and tried from time to time. Perhaps the most effective method of destroying the foam is to direct a fine spray on to the breast-box or between the sieves, as shown in 36. A large amount of water drains through the wire into the "saveall," a tray placed beneath to catch it, whence it is returned by auxiliary pumps to the mixing-box to be used over again.

In between two of the suction boxes is sometimes fixed a "dandy roll" [38], by means of which the "laid" and the "wove" texture, as also the water-marking, is imparted to the web. The dandy roll rests on the surface of the wet stuff, and is revolved by contact with the moving wire. It is made of brass or gunmetal, and consists of two spindles, one inside the other, to which are fitted at regular intervals numerous thin discs or flanges as support to the wire gauze which covers the roll. It is necessary to provide that just sufficient water remains in the stuff as it reaches the dandy: this is controlled by the suction boxes. On the surface of this gauze is fastened the watermark, consisting of lettering and design. In place of vacuum pumps a vacuum ejector is often used whereby an absolutely uniform vacuum can be maintained.

After the suction from the last box, which makes all the difference between a "wet" and "dry" surface, the wire bearing the web of partially-formed paper dips down and passes between the "couch rolls," the top roll of which is covered with a thick specially manufactured felt jacket, made all in one piece so as to fit on without a seam. Pressure exerted by this upon the lower roll bearing the wire further removes the water. On the top of the "couch roll" is a "doctor," consisting of a cross-piece of wood covered with felt, pressing tight against the surface so as to form a channel along which water can be made to flow to remove any dirt or loose material. The paper, which can now move without a support, passes from the couch rolls to the first wet felt, which is a continuous web of felt passing between squeezing rolls where more water is removed, and thence to the second wet felt and squeezing rolls, and sometimes to a third. The web of paper is manœuvred so that first the under-side and then the top side comes into contact with the wet felts, thus insuring that both sides receive as far as possible equal treatment. The web now contains, say, 27 per cent. dry weight of fibre and 73 per cent. water. This water has to be driven off by heat, as pressure has removed all that it possibly can. This is accomplished by leading the web in zig-zag fashion over cylinders usually heated by exhaust steam from the engine which drives the paper machine. The web is kept in contact with the cylinders by the "dry felts," and when perfectly dry is either passed over the calenders, reeled and sold in the rough, or taken to the sizing room. The dry felts are kept dry by additional cylinders (felt dryers) kept straight by autoguides and kept taut by autostretchers.



41. LUMSDEN'S PATENT REELER

Finished paper generally reaches the cutter [37] or reel [41] in an over-dry condition—that is, containing less than its normal moisture. On storage or exposure the paper, of course, regains its normal moisture.

Board Machine. In 1809 Dickinson invented a machine for making paper on an entirely different principle to the Fourdrinier. It consisted essentially of a cylinder covered with wire gauze revolving vertically immersed in a trough of beaten pulp. The water passes through the gauze, leaving a film of paper on the surface, which was pressed against an upper roll revolving in contact with the gauze-covered cylinder, and then passed by means of an endless felt to the couch rolls and afterwards dried over steam cylinders. These first machines were, and still are, used for making special papers; but the principle is applied in the modern board machine. Figure 39 shows a machine on the above principle which will make triplex boards. Each cylinder gathers up its quota of pulp and transfers it to a felt which moves in the direction of the arrows. The mass on the felt, from being one thickness or ply at the first cylinder, becomes successively 2, 3, 4, 5, 6 ply. The two outside cylinders constitute the outside surfaces, which may be of different colours and composition. The four middle cylinders build up the "middles." The middles is all of one composition, and is reckoned as one, so that the board is called triplex because it has three distinct layers. Three cylinders are enough for a thin board, but five are needed for a thick one, and as the thickness of the "middles" is often much more than half the total thickness, more cylinders are required to build it up. The outer cylinders often give merely a thinnish coating of superior material, the middles being often made of mechanical, broke, and very cheap materials.

Uses of Wood Pulp. There are a number of ways in which wood pulp is used outside that of making "news" and other cheap papers. One of these, which is likely to attain considerable importance in the future, is the manufacture of paper yarn. This, as the name indicates, consists of continuous threads of paper which can be woven into the form of a material either with or without the addition of a small quantity of cotton, wool, "shoddy," etc., and the resulting products are likely to prove valuable substitutes for jute baggings, coarse tailoring stuffs, etc.

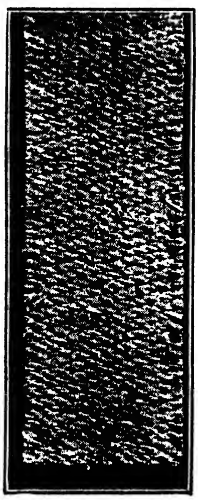
If we refer back to the different fibres used in paper-making it will be remembered that the length varies very much, cotton, linen, and some wood fibres being an inch or more in length, while straw and esparto fibres measure only a small fraction of an inch. Although the ultimate fibre of jute is short, the filaments, the real spinning units, are long. The paper-maker can use any of these fibres, but the spinner only the longer ones. This is largely owing to the different methods employed in the two industries.

In the manufacture of paper yarn, two qualities are combined—namely, the felting and spinning

qualities. The fibres are first treated so as to make paper, which is then cut into long strips. These strips are then treated in spinning machinery, similarly to "sliver" [see page 1723], with the formation of threads. Although the process is a new one, it has already undergone quite a number of modifications and improvements. We shall confine ourselves to a description of the most recent.

How Paper is Prepared for Spinning. Of the modern methods there are two, known respectively as Türk's and Kron's processes. Both of these start by making a thin sheet of unsized pulp, and the fibrous material is usually wood-pulp, preferably chemical wood. Although it is quite possible to introduce rag, hemp, linen, or other fibres, it has yet to be proved whether the advantage gained would compensate for the extra cost. It is considered necessary to form the thin sheet of pulp into a number of individual strips, to avoid the expense of cutting a ready-framed wide web into continuous narrow strips, as well as to give the natural or deckle edge which, to a paper-maker, has obvious advantages. Türk, who uses a cylinder or board machine, fixes to the wire cloth a number of parallel metal strips encircling the cylinder. As the water cannot permeate the cloth where it is covered up by metal strips, no fibre is deposited on these points, and the sheet of pulp, when formed, is already separated into a number of strips corresponding to the distance between the strips of metal, or, in other words, to the available width of exposed wire cloth. The general arrangement is shown in **40**. M is the cylinder of the board machine, F′ the endless felt, DD′ couch rolls, and N the condenser. [For a description of the action of a condenser, see page 1546.]

Kron proceeds by a somewhat improved method. He uses an ordinary Fourdrinier machine, and divides the thin sheet of pulp by numerous fine jets of water directed on to it, so that a sheet is obtained divided into strips and held together only here and there by stray fibres. It is partially dried by passing round a big steam-heated drying cylinder, and is then wound up to form a reel. By working with the Fourdrinier machine it is claimed that thinner pulp sheets can be produced, the machine can run more rapidly, and there is less waste space on the wire cloth than in Türk's process. A sheet produced on a wide machine may be divided into as many as 400 strips.



42. PAPER YARN SACKING

Paper Strips Spun. A reel of strips still damp—that is, containing 30 per cent. to 40 per cent. of moisture—is now taken to a spinning frame, by the aid of which each thin strip is twisted into a thread. The twisting of the strip greatly increases its strength.

As the strip contains 30 per cent. to 40 per cent. of water, when twisted into threads the resulting threads have to be dried before final reeling. For this purpose the material is placed in special drying rooms supplied with hot air.

The chief use of pulp yarn, or "silvaline," as it is called, when prepared by Kron's process will probably be to replace jute for preparing coarse sacking, jute bagging, etc. Figure **42** is a piece of sacking made from paper yarn; **43** shows samples of cord made from the same material. The yarn can be dyed as easily as paper, either by adding colour to the pulp or by dyeing the woven or spun material. Figure **44** is an example of a woven design.

Papers in Common Use. Even to enumerate in an article of considerable length the different kinds of papers now manufactured would be an impossibility. The classification below is merely one to give the student some general idea of those kinds of paper which must be more or less familiar to him. We have, furthermore, generally omitted such kinds as have been already referred to when dealing with the actual manufacture of paper.

BLOTTING PAPER. Formerly made entirely from soft rags, but now often made from special kinds of wood pulp and other fibres. Should be soft to the touch and handle well, and possess spongy, pliable qualities. Should be capable of being used repeatedly without smudging the writing.

BANK AND LOAN PAPERS. These are generally made of rags with a preponderance of linen. Beaten a long time with dull tackle and well sized with gelatin. Thin papers with good rattle.

"BROWNS." The best are made from rope sized with glue or gelatin and "loft dried." The commoner are made with a mixture of jute bagging, and unbleached wood pulp. Sized with resin and dried over cylinders. Should fold well and have good strength and stretch. Improve on keeping.

BOOK PAPERS. *Edition de luxe*, hand-made rag papers sized with gelatin, leaving deckle edge untrimmed. Less expensive, made with a mixture of wood pulp on machine. The best printing qualities got by addition of esparto pulp. Common printings made with mixtures of chemical and mechanical pulps. The commonest for cheap literature, little better than "news."

BIBLE AND INDIA PAPERS. Monopoly of one firm in this country, who make the finest Bible paper in the world. Excellent substitutes in Italian and German makes. Pleasing surface, and very thin and smooth. Highly opaque to prevent printed matter from being seen through. A thousand pages of thinnest occupy a little over ½ in. thickness, and yet hardly show printed matter through when read. Composition and mode of manufacture a profound secret.

CARTRIDGE. Thick papers of various composition. Must have good resistance to penetration and stand contact with powders. It has recently been discovered that nitro-glycerine exudes through some papers—rendering the cartridge useless—but not through others.

COUPON. Best hand-made with linen, well sized. Special water-mark designs. Such paper must be specially beaten to give a clear water-mark.

CELLULOID PAPER. Very thin tissue, specially made with pure cotton for nitration and conversion into celluloid.

CORPSE WRAPPING. Very tough, black paper. Retains strength when wetted; very lasting qualities. Suitable for wrapping and conveyance of fish, fruit, and other perishable articles that require protection from damp.

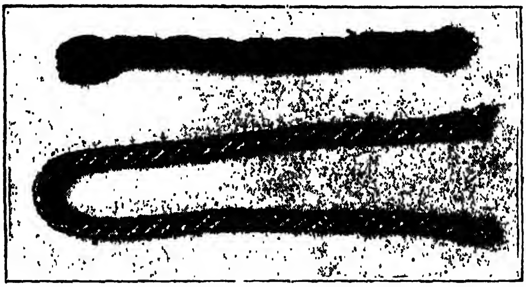
COPYING PAPER. Thin tissue, usually made from rags. Must stand wetting and take transfer of ink. Generally British; but sometimes Japanese manufacture from native fibre.

CHART PAPER. Must retain its dimensions and surface under changes of atmosphere.

CUTLERY PAPERS. Usually strong manilla; rough texture, good strength and stretch. Must be free from all substances calculated to rust or tarnish cutlery. Specially made.

CIGARETTE PAPERS. Foreign manufacture. Best made from rice straw. Thoroughly freed from encrusting matter, ash, or trace of chemicals. Must possess proper wrapping qualities.

DRAWING PAPERS. The best are hand-made from rags. Must possess special "tooth," which improves with storage and age. Some dates of "Whatman's" are specially prized by artists on account of pleasing surface. Cheaper drawings machine-made from rags; suitable for draughtsmen, engineers, and others. All tub-sized with gelatin. Should take the wash properly and show small but regular expansion when wetted so that the sheet stretches uniformly flat on drying.



43. PAPER YARN CORD

DUPLEX PAPERS. Made on cylinder machines one-half one colour and the other half a different colour, according to requirements. Suitable for box-making. *Triplex* made similarly in three layers or plies.

Usually made of commoner material such as "mechanical" or "broke" papers. The outside surface is sometimes made of mixtures of straw and chemical pulp; with or without colouring.

FILTER PAPERS. Made somewhat like blottings, but with special texture so as to retain sufficient strength when wetted. Made mostly from rags. For chemical work specially treated with hydrochloric and hydrofluoric acids to get rid of ash. Largely of foreign manufacture. Good filter paper now made with wood pulp.

FEATHER - WEIGHT PAPERS. Popular with publishers of books. Can be made of bleached sulphite or of esparto. Bleaching done quickly. Machine tackle must be manipulated to give large "bulk." "Wet felt" must be of close texture to avoid felt mark. Press rolls and couchers should be hung a little so as to give "bulk."

44. WOVEN PAPER YARN

INSULATING PAPER. For wrapping round wires for cable insulation. Large quantities used. The best made from manilla or hemp. Very strong, thoroughly thick and pliable. Mostly sized with resin. Prepared so as to ensure the greatest possible durability. Some now prepared from wood pulp.

"KRAFT." Unbleached paper, mostly Swedish manufacture, prepared from a particular kind of wood pulp. A large firm are about to make this paper in England. Good rattle, hardness and stretch. Much in favour for wrapping, etc.

METALLIC AND SIMILAR PAPERS. The fibres of papers are sometimes incorporated with metallic particles, and used for book covers or the surface is coated with aluminium, bronze powder, etc., for fancy purposes

MARL PAPERS. Brown papers with "marl," or mottled effect, produced by use of material specially manipulated. Strong and excellent.

MOTTLED AND MARBLED PAPERS. Made with cotton, linen, cotton and union rags, or with specially and separately dyed cotton, jute, wood or sulphite wood fibres. The *Silurian* writing papers are made in this manner.

"NEWS." By far the greatest output of all kinds, and lowest in price. Formerly made with rags, esparto, but now from mixtures of mechanical and chemical wood. The cheapest news made in England contains 80 per cent. mechanical and 20 per cent. sulphite, sized with a little resin. The custom of adding about 10 per cent. of clay is largely abandoned. The better qualities contain larger proportions of sulphite.

PARCHMENT PAPER. Made by passing an endless web of paper through a bath of sulphuric acid, which is washed out and the paper dried. Special qualities, strong when wet, water resistant, suitable for protecting foodstuffs against damp and air, as for tops of jam-pots and similar purposes. Takes the place of real parchment for such purposes, where moderate strength only is required.

PHOTOGRAPHIC PAPERS. Specially made from rag. Manipulation of fibres a secret. The best is of foreign manufacture. The plant used is of special construction so as to render fibres free from all injurious metallic and chemical substances. Must have suitable surface and stand the washing. Good photographic now made in England.

TYPEWRITING PAPERS. Suitable composition for high class, 40 per cent. bleached sulphite, 60 per cent. strong linen, well beaten and passed through refiner. Some American papers are mostly sulphite and are very well milled. Sized slightly with resin. With or without mineral.

WRITING PAPERS. Made formerly entirely of rags; well sized with gelatin, and coloured where necessary with ultramarine or smalts. Loaded with pearl hardening, and sized with resin and gelatin. Now increasing quantities of wood pulp in admixture. Some writings contain esparto with other fibres. Commoner writings contain "broke," some "mechanical," the rest chemical and clay. Sized with resin only.

WILLESDEN PAPER AND CANVAS. Treated in solution of copper dissolved in ammonia, which makes the paper strong and rot proof. Suitable for building purposes, and for use where great durability is required. Colour generally of greenish cast, due to presence of copper, which, however, can be obviated by substituting zinc for the copper.

Continued

Continued from page 6252

EARTH & THE INNER PLANETS

The Motions of Mercury and Venus inside the Earth's Orbit round the Sun. Measuring the Sun's Distance. Weighing the Earth

By W. E. GARRETT FISHER

THERE are two known planets which move round the sun in orbits smaller than that of the earth, and as this leads to certain peculiarities in their appearance, which distinguish them from the other planets to human eyes, we may deal with them before passing on to the earth. These two, of course, are Mercury and Venus. More than once the discovery of a planet still nearer to the sun than Mercury has been announced, and this supposed planet has even been christened Vulcan, but it is almost certain that the alleged observations of it are misleading. There might, indeed, be a planet nearer to the sun than Mercury without our being sure of its existence, since its light would almost always be drowned in the solar radiance. Certain peculiarities in the movements of Mercury have been attributed to perturbations caused by the attraction of an inner planet, but the careful search made for this planet during eclipses of the sun has hitherto proved unsuccessful.

Mercury. Mercury, the inmost of the known planets, moves round the sun at a mean distance of about 36,000,000 miles. It is the smallest of the major planets, being only 3,030 miles in diameter, or a little more than one-third the size of the earth. The plane of Mercury's orbit is inclined at an angle of 7° to the ecliptic, which is more than the inclination of any other planetary orbit. The Zodiac had to be made 16° wide in order to include the apparent movements of Mercury.

The year of Mercury, or the time in which it completes its revolution round the sun, is equal to 88 of our days. Mercury certainly rotates on its axis, but it has been extremely difficult to determine the period of this rotation, owing to the lack of definite markings on the planet's surface, which, as it is seen by us, probably consists of a mass of clouds. The latest conclusion is that Mercury rotates on its axis in the same time as it completes a revolution in its orbit—88 days. In other words, its day is equal to its year, and it always presents the same face to the sun, just as—and probably for the same reason—the moon always presents the same face to the earth.

When the Day is Equal to the Year. As will be shown when we come to study the case of the moon, there are reasons for supposing that this will be the ultimate condition of all the planets, including our own—namely, that their period of rotation and of revolution round the sun will become the same. At that very distant date the dwellers on the earth (if they be not extinct) will find their planet divided into two nearly equal zones, one of which enjoys perpetual day whilst the other is sunk in everlasting night. The sun, instead of moving regularly round the earth, will only vibrate backwards and forwards in the sky for a comparatively short distance. All life will necessarily congregate on the side of the earth which faces the sun, since the opposite side will be chilled down to a temperature nearly approaching that of interstellar space. As a matter of fact, one side of the earth would thus probably become too hot for habitation and the other would certainly be too cold. The only chance for man's continued existence would then be that he should retire, as Mr. Wells supposes the inhabitants of the moon have long ago done, into vast caverns and underground cities, or possibly eke out a lingering existence in the narrow temperate zone which might still exist near the meeting place of eternal day and night. As far as Mercury is concerned this state of things has already been reached, and there is little doubt that this planet is entirely unfitted for the abode of any kind of life which we can mention. Mercury possesses no satellites. Its apparent movements and orbit will be described along with those of Venus.

Venus. Venus, which is the brightest and most beautiful star in the heavens, is our nearest planetary neighbour, coming at times within about 25,000,000 miles of the earth. Its distance from the sun is 67,200,000 miles, and it therefore receives just twice as much heat and light as the earth. Its orbit is almost exactly circular, and the length of its year is 225 days. Its orbit is inclined to the ecliptic at an angle of 3½°. The diameter of Venus is about 7,700 miles, or very slightly less than that of the earth.

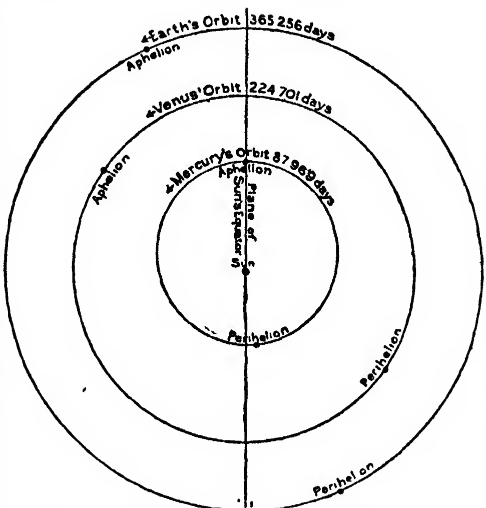
The planet rotates on its axis, but here again, as in the case of Mercury, there is great difficulty in measuring its angular velocity, owing to the apparent covering of the planet with clouds which afford no definite fixed point for our telescopes to watch. The best modern opinion is that Venus, like Mercury, has a day of the same length as its year, and continually presents the same face to the sun. If this be the case, Venus, like Mercury, must be unfitted to be the abode of life, and it is, to say the least, doubtful whether the proximity of these planets to the sun ever allowed life, which seems to us to be limited to a very moderate range of temperature, to be developed upon their surface. Venus appears to be surrounded by an atmosphere of considerable density, and possesses no known satellite.

Morning and Evening Stars. The apparent motions of Mercury and Venus present great similarity, and may conveniently be described together. They are both visible at different times of the year as morning or as evening stars. Venus is pre-eminently known as the Evening Star, or Morning Star, on account of its resplendent beauty, "sweet Hesper-Phosphor, double name." Mercury, though very nearly as bright as Venus, is very much less easy to perceive, on account of its greater proximity to the sun. The great astronomer Copernicus is said to have passed his whole life in unavailing endeavours to perceive Mercury—though this is perhaps an exaggeration. The planet can be seen several times a year by those who know where to look, but it is generally drowned in the sun's radiance. Everyone, however, is familiar with the brilliant appearance of Venus, whether shining as the Evening Star after sunset

or as the Morning Star which heralds the appearance of the sun.

Apparent Motions of Mercury and Venus. The essential peculiarity of the motions of Mercury and Venus is that they are never seen very far away from the sun. Mercury never remains visible for more than an hour or so after the sun has set, and Venus is always seen as an evening star in the west or a morning star in the eastern sky. They are never visible, like others of the planets, right overhead. If we study the motions of Mercury or Venus from night to night, we very soon begin to perceive their regular changes. Venus, being so much easier to perceive, offers a very good object for the young astronomer to watch from week to week.

After a while it becomes apparent that this planet moves backwards and forwards on either side of the sun, within a limited range. Suppose that at the time of beginning our watch Venus is shining as the brilliant Evening Star after sunset. For a time it seems to travel farther and farther eastward, or away from the sun, and consequently to remain visible for a longer time each evening. But the time soon comes when we notice that it ceases to go farther away from the sun; it remains stationary for a night or two, and then it begins to travel back towards the sun until it is entirely swallowed up in the solar radiance and is invisible for a time. After a short period of invisibility, Venus emerges on the other side of the sun and consequently becomes visible in the morning shortly before sunrise. As it continues to move to the west of the sun, it rises earlier and earlier, till again it reaches the limit of its western motion, remains stationary for a short time, and then again starts on its eastward journey back toward the sun, ultimately to emerge on the eastern side of the sun and again become the Evening Star.



22. ORBITS OF VENUS AND MERCURY

At the dawn of astronomy the Morning and Evening Star were supposed to be distinct bodies, which were named Phosphorus and Hesperus; one of the first astronomical discoveries was that they were really the same star, which journeyed backwards and forwards from one side of the sun to the other. The apparent motion of Mercury is precisely similar, though less easy to watch because it is confined within much narrower limits. The angular distance of these planets from the sun on either side is known as their *elongation*. When they are in a straight line with the sun and earth, they are said to be in *conjunction*.

The Orbits of the Evening Stars. The real explanation of these motions is not difficult to comprehend. Venus and Mercury both move round the sun in roughly circular orbits inside that of the earth [22]. Consequently, the effect of perspective shows them to us as if they moved in a straight line backwards and forwards from the sun [23]. If the earth were at rest, each planet would complete its double oscillation in the period of its year. Venus, for instance, would pass from her farthest eastern to her farthest western elongation in 225 days. But as the earth is also in motion round the sun this simple motion is complicated by our own motion. Instead of the easterly and westerly motions of Venus or Mercury being completed in the same time, the westward swing appears to be completed much more rapidly than the eastward, because in the former case the earth's motion assists that of the planet, but in the latter it detracts from it. Thus, Venus moves rapidly from its easterly elongation as the Evening Star to its westerly elongation as the Morning Star, and travels back again much more slowly.

Its *synodic* period, or the period in which it completes this cycle with reference to the earth, is 584 days; more than three-quarters of this period is occupied in the slower half of the journey. The synodic period of Mercury is 116 days. The greatest elongation of Venus, or its apparent distance from the sun, varies from 47° to 48°, which means that when it is farthest away from the sun it may be visible for more than three hours after sunset or before sunrise. Mercury's greatest elongation varies from 18° to 28°, so that under the most favourable circumstances it is visible for less than two hours before sunrise or after sunset.

Phases of Mercury and Venus. One of the first discoveries made by Galileo's telescope was that these two planets, Mercury and Venus, exhibited phases like those of the moon. The other planets always shine with a full circular disc, though it varies in apparent size with their varying distance from the earth. But Venus and Mercury, when seen through a telescope, present the phases with which we are so familiar in the moon. These phases will be readily understood by a glance at the diagram [23]. They depend, of course, upon the fact that the planet derives its light by reflection from the central sun, and moves round the sun between it and the earth. When at *inferior* conjunction the planet is between us and the sun; we see only its dark side, or, in other words, do not see it at all. As a matter of fact, it is then swallowed up in the sunbeams, and the only occasion when we have an opportunity of testing the truth of this part of the theory is when Venus or Mercury passes right between us and the sun. It then appears in *transit* as a circular black spot on the sun's disc.

At the *superior* conjunction it is beyond the sun, and nearly in a straight line with it from the earth. At these times we cannot see it at all, because of the solar brilliance; but if we could see it we should see its disc fully illuminated like that of the moon. At the times of greatest elongation the planet appears like a half-moon; a good field-glass or small telescope will clearly show these phases when Venus is shining as the Evening Star, from two to three hours after sunset. At other times the

planet exhibits various lunar phases, being gibbous as it passes from one elongation to the other beyond the sun, and waning to a crescent as it completes the other half of its orbit. The same explanation applies to Mercury, though its proximity to the sun makes its phases less easy to follow.

The Earth as a Planet. The third planet in order of distance from the sun is by far the most interesting of all, because it is the earth on which we live. Some explanation must here be given of the way in which astronomers have measured the size of the earth's *orbit*, or annual path round the sun, which affords a basis for all our measures of celestial distances. In the first place it must be said, though the explanation of the fact must be looked for in more advanced treatises, that the mathematical theory of astronomy, based on Newton's law of gravitation, gives us all the *relative* measurements of the solar system with great accuracy, but does not determine any one of them *absolutely*. That is to say, if we know any one of these measurements, we can easily calculate all the others in terms of it. The most obvious measurement to use as a basis or unit is the distance of the earth from the sun. The early Greek astronomers made ingenious but futile attempts to calculate this by geometrical constructions, but the problem was too complicated for them. Modern researches have been carried on by means of two distinct methods, which have yielded results practically similar, and have enabled us to measure the earth's mean distance from the sun within a very small margin of error.

The Sun's Parallax. The first and older of these methods depends on what is called *parallax*. Parallax is a name given to the difference between the directions of a celestial body as seen from two different points. It is the same principle which is utilised in the trigonometrical operations of ordinary surveying. The surveyor measures the base line AB of a triangle [**25**] in order to determine the position of a third point C. He then sets up his theodolite first at A, and then at B, and measures the angles CAB and CBA—or, in popular language, the difference of direction of C, as seen from A and B. When the length AB and any two of the angles of the triangle ABC are known, it is a simple trigonometrical calculation to find the length of the other sides CA and CB [see MATHEMATICS, pages 6231 and 6373]. In celestial surveying, or astronomy, we begin by measuring a base line on the earth.

We can now understand the principle on which the measurement of the sun's distance by its parallax is based. In the diagram let A and B represent two stations on the earth, separated by a known distance AB, and let C represent the sun or planet whose distance it is desired to measure. If two observers simultaneously observe the direction of the sun or planet, and combine their observations, we then have a triangle in which the length AB and the angles CAB and CBA are all known, and it then becomes possible to calculate the distance AC or BC.

This is merely a rough illustration of the method used, which is really much more elaborate, and involves a great many minute corrections which we have no space to explain. But the principle of it will now be clear. Such measurements require to be made with the greatest accuracy, because the distance of the sun from the earth is so great in comparison with the longest base that can be drawn on the earth that the difference between the directions from which it is seen from any two points at the same time is exceedingly small.

There is, however, another quite independent method of estimating the distance of the sun. It will be clear that we could measure the distance from London to Edinburgh with considerable accuracy if we knew that a motor-car, built so as to run uniformly at twenty miles an hour, had taken a specified time over the journey. We have a messenger of this kind, warranted to move with a perfectly uniform speed, in the ethereal vibrations which constitute light. It was discovered 200 years ago that light did not traverse space instantaneously, but took a definite time in completing a journey of a given length. In the course of its yearly journey, the earth moves from end to end of the diameter of its orbit—a gigantic base line of more than 180,000,000 miles.

The Sun's Distance Measured by the Speed of Light. The Danish astronomer Roemer found that his observations of the eclipses of Jupiter's satellites, whose motions are so well known that the times of these eclipses can be calculated in advance, varied as much as sixteen minutes from one another at different times of the year. Some of his observations showed that these eclipses happened about eight minutes sooner than the predicted time. Six months later the observation was eight minutes behind the time given in the tables. It is from such discrepancies between calculated events and observations made as accurately as possible that a great many of the most valuable scientific discoveries have arisen, since they always point to the existence of some previously unsuspected cause which modifies the phenomena under study.

Roemer, on thinking it out carefully, saw that the only difference in the conditions between the two sets of observations was that the earth was at opposite ends of its annual journey; in other words its distance from Jupiter, which does not move far in six months, varied in that time by about the diameter of the earth's orbit, or twice the distance from the sun to the earth. He then saw that if he assumed that light took about 8 minutes to travel from the earth to the sun, the discrepancies between his observations and the predicted times of eclipses might be satisfactorily explained. These eclipses having been calculated with the sun as starting point, when the earth was at its nearest approach to Jupiter light from that planet, bearing the message of the eclipse, would reach it eight minutes sooner than the sun, and, consequently, the eclipse would seem to happen eight minutes too soon. Similarly, six months afterwards, when the earth had rushed to the other end of its orbit, the light would have to pass the sun and travel on as far again, and the eclipse would appear to happen eight minutes later.

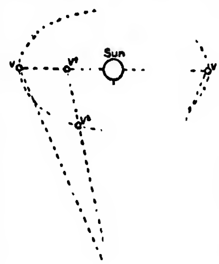
The Fundamental Astronomical Unit. It is possible with the exact instruments of modern science to measure the velocity of light in our laboratories, and from such observations as those of Roemer can be measured, with equal accuracy, the time which light takes to travel from the earth to the sun. This physical method of measuring the sun's distance is quite independent of the parallactic or astronomical one, and the two give results closely in accordance with one another. From these various methods the earth's distance from the sun is known to be about 92,900,000 miles, the probable error not being greater than 100,000 miles either way. This distance of the sun is the fundamental unit of astronomical measurements, in terms of which all others are calculated, though we shall see when we come to the fixed stars that another and larger unit has there to be adopted.

When the actual distance of the earth from the sun has been found by either of these methods, all the other dimensions of the earth's orbit and the rest of the solar system can be calculated from it. Another very important unit is the earth's *mass*, which is found by experiment, and from which the laws of dynamics enable us to calculate the mass of all other bodies which compose our system. There are various methods of weighing the earth, which all depend on the same principle as that by which the mass of any comparatively small quantity of matter is determined.

The Mass of the Earth. The most trustworthy of these is that used by Cavendish, the famous chemist of the eighteenth century, and generally associated with his name, though later workers have obtained still more accurate results from its use. The law of gravitation tells us that two masses attract one another with a force which is always proportional to the product of their masses. The *Cavendish experiment* consists in measuring the attraction which a massive globe of lead has for a small pith ball, and comparing this attraction with the weight of the pith ball. The weight of a body is simply a convenient way of measuring the attraction which the earth has for it; we are, therefore, able to say that the mass of the earth is to the mass of the leaden globe as the weight of the pith ball is to the force with which the leaden globe would attract it if placed at the same distance away from it as the centre of the earth, from which terrestrial gravitation is measured. The observation is a very delicate one, as it involves measuring forces not greater than the weight of the millionth part of a grain; but considerable reliance is placed on its results, and the density of the earth is known with fair accuracy to be about $5\frac{1}{2}$ times that of water.

Other methods used for determining the mass of the earth, such as the Schehallien and the Harton experiments, are much less trustworthy, but on the whole lead to the same result. From the known size of the earth we can calculate its volume, and its mass being determined by the Cavendish experiment gives us its mean density. The actual mass of the earth is 6×10^{21} tons—or 6 with 21 noughts after it. This gigantic mass cannot be realised by any mental process of which we are capable. In astronomical work the mass of the earth is taken as the unit to which the mass of other celestial bodies are referred. Thus, the mass of the sun is given as 332,000 times that of the earth; and Jupiter, the largest of the planets, is 317·7 times as massive as the earth. The smallest of the telescopic planets is probably much less than $\frac{1}{10000}$th part of the earth's mass.

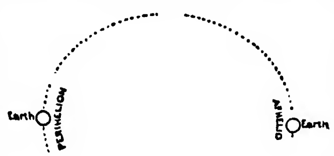
The Orbit of the Earth. The earth's orbit, as we have already seen, is an ellipse of which the sun occupies one focus. This orbit is very nearly circular, the eccentricity of the ellipse being only about $\frac{1}{60}$th [24]. The points in the orbit at which the earth is nearest to and farthest from the sun are respectively known as the *perihelion* and the *aphelion*. The earth reaches its perihelion about December 31st, and its aphelion early in July. It would seem at first that the earth should be nearest to the sun in summer and farthest from it in winter. But our seasons depend upon the fact that the earth rotates about an axis which is inclined to the plane of its orbit at an angle of rather more than 23°. This axis always remains pointing to the same points in the sky, which are known as the celestial poles.



23. APPARENT MOTION OF VENUS

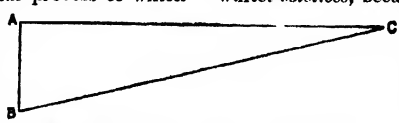
When the earth is in perihelion its north pole is inclined away from the sun, whence it follows that in the northern hemisphere the nights are then longer than the days, and the total quantity of light and heat which that hemisphere receives from the sun is a minimum, while in the southern hemisphere these conditions are exactly reversed. Consequently when the earth is in perihelion it is mid-winter in the northern and mid-summer in the southern hemisphere; when it is in aphelion it is mid-summer in the northern and mid-winter in the southern.

A Model of the Season Changes. The student will find it quite easy to understand why this is the case if he will make a rough model of the earth by running a knitting-needle through the core of an apple, and trace the equator round the middle of the apple at right angles to this axis. If he then takes a lighted candle to represent the sun and moves this model earth round it, taking care to keep the axis inclined at an angle of about 23° to the plane of the table on which the lighted candle stands, he will get a very good idea of the seasonal changes which are a necessary consequence of such physical arrangements.



24. THE EARTH'S ORBIT

He will also see that there are two, and only two, points in the earth's orbit at which the plane of its equator passes through the sun. When the earth is at these points both hemispheres are equally illuminated, and day and night are of equal length, whence these points in the orbit are known as the vernal (or spring) and autumnal *equinoxes*. The points in the orbit at which the northern hemisphere has respectively its maximum and minimum illumination are the summer and winter *solstices*, because at these points in the orbit the sun has reached its highest place in the sky and appears to stand still for a day or two before beginning its reverse journey. The sun's apparent motion in the sky is compounded of the earth's rotation and its revolution in the annual orbit. Every day it travels across the heavens from east to west, because the earth is rotating from west to east and carrying the observer with it. Every year the point where the sun *culminates*, or reaches its highest place at noon, travels steadily upwards in the sky from mid-winter to mid-summer and then sinks down again at the same rate.



25. TRIGONOMETRICAL PARALLAX DETERMINATION

Continued

SHIP MANAGEMENT continued from page 6366

THE DUTIES OF A SAILOR

The Apprentice Sailor. Making Knots and Hitches. The Management of Sails. Rules of the Road. Signalling at Sea

By J. P. LORD

THE basis upon which the whole calling of a sailor rests is a sound knowledge of seamanship and navigation. Seamanship must be learnt first, for there is little benefit in being able to find out the position of a ship and the direction in which she is to sail if one cannot make her take that direction. For this reason the Board of Trade insists that the candidate who fails in seamanship shall go to sea for six months prior to presenting himself again for examination.

First Duties. The first matter that will engage the attention of the apprentice or boy on board a sailing vessel will be to make himself acquainted with the names and positions of the several sails, and more particularly the numerous ropes pertaining to or in the management of them—namely, the *yards* on the masts, and the *braces* by which they are trimmed to the wind. Then the *halyards* and *downhauls* and *reef-tackles* by which they are controlled will have to be learned. The majority of these ropes are led through *fairleads* attached to the *shrouds* and *backstays* on each of the masts, but some lead down by the sides of the masts themselves. The names and position of these ropes are not difficult to learn, but this knowledge is of more importance than almost anything to which a boy can give his attention. His duties during his watch on deck will be concerned with certain articles of ship's furniture—namely, the deck-buckets, brooms and scrubbing brushes, swabs and cloths, etc. These he will have to get ready for the daily wash down of decks and paintwork, and see to their being put carefully away after this operation is finished. The boatswain's gear, such as marlin-spikes, serving-boards and mallets, spunyarn and marline, tar and grease-pots, used when repairs or renewals of ship's running or standing rigging are going forward, will have to be fetched and returned by the young sailor. He will be in attendance on the seamen engaged on this work either on deck or aloft, and in this manner gains a knowledge of how a ship's equipment is kept in working order, and the chafing of gear prevented as much as possible. As youngest apprentice or boy, his place in his watch on deck at night will be on the lee side of the poop, handy to the officer of his watch; he will keep the time and strike the bell every half-hour, and see that the binnacle lamps are kept burning brightly. There is a good deal of drudgery for the beginner, but if his heart is in his work he will soon be given more responsibility.

Knots. The principal knots that a sailor must be able to tie are as follow:

OVERHAND KNOT, OR SIMPLE KNOT [1]. Pass the end of the rope round the standing part, and through the bight. The standing part is supposed to be the fixed part of the rope, the end is the free end, and the bight is a loop formed by the rope.

FIGURE OF EIGHT [2]. Pass the end of the rope round the standing part, under its own part, and through the bight. Its own part is where the end first meets a portion of itself which has been used.

HANDSPIKE HITCH [3]. Rope fastened at each end. Make a bight in it. Pass handspike down through bight, under underneath portion of the rope, and force it up till the end, lifting the rope, passes over the other side of bight. On pulling out the handspike the rope is again free.

COMMON SHEET BEND [4]. Two ropes. Form bight with 1. Take end of second rope, pass through bight of 1, and round both parts of 1, and then under its own part. This will jam against the edge of the bight.

COMMON BOWLINE [5]. One rope Some little distance from the end form a bight in rope with a half twist, making a loop. Pass end up through this loop, round standing part and down again through loop

REEF KNOT [6] Joining two ropes Make bight in 1, with end and standing part side by side. Pass end of 2 up through bight, round both parts of 2 and down through bight again. Or pass end of 1 round end of 2, then bring two ends back to their standing parts, passing one part round the other so that two parts of each rope pass through the bight in the same direction.

CARRICK BEND [7]. Two ropes Cross bight of 1. Pass end of 2 through bight, over end of 1, round standing part of 1, over its own part, and through bight again, both parts coming out of bight at different sides.

SLIP KNOT. This is the common slip noose of the schoolboy.

FLEMISH LOOP [8] Make slip knot, and then with end make overhand knot round standing part, away from loop.

CHAIN KNOT AND TOGGLE [9]. Chain knot is a succession of slip knots, known to schoolboys as the drummer's knot or rat's tail. The toggle is a short bar passed through the last loop The chain knot is made by making a bight on the rope and crossing it Pass hand through bight and catch standing part. Pull this through, forming loop Repeat this for as many slip knots as may be required Pass toggle through last loop, and haul on end to tighten up.

BOWLINE ON A BIGHT [10] Place bight over the two end parts, and form loop with bight through, pass bight under the two end parts, and bring it back, through which reeve the bight formed by the double parts.

SHEEPSHANK [11]. This is a form of hitch used for shortening a warp. A piece of the middle of the rope is taken up so as to form three parallel strands, or two bights. Round the end of each bight a hitch is made with the part leading to the end. As long as the strain is maintained the knot holds. When it is desired to let out the rope one of the long sides of the bight can be prised out, or one of the hitches slackened and the end of the bight withdrawn.

CATSPAW [12]. Take a bight of rope, and from this form two bights, holding one part in each hand. Now twist each of these bights several times, with the result that you will have two small loops, each of which terminates in a twisted double rope. A spike, bar, or hook of a tackle can then be passed through the loops.

Hitches. These are used for securing pieces of timber, for attaching a rope to a hook or shackle, and for making fast cargo and weights to be hoisted. They must be mastered thoroughly, for on their security much depends.

HALF HITCH [13]. Pass the end round the spar and its own standing part, and then reeve under its own part.

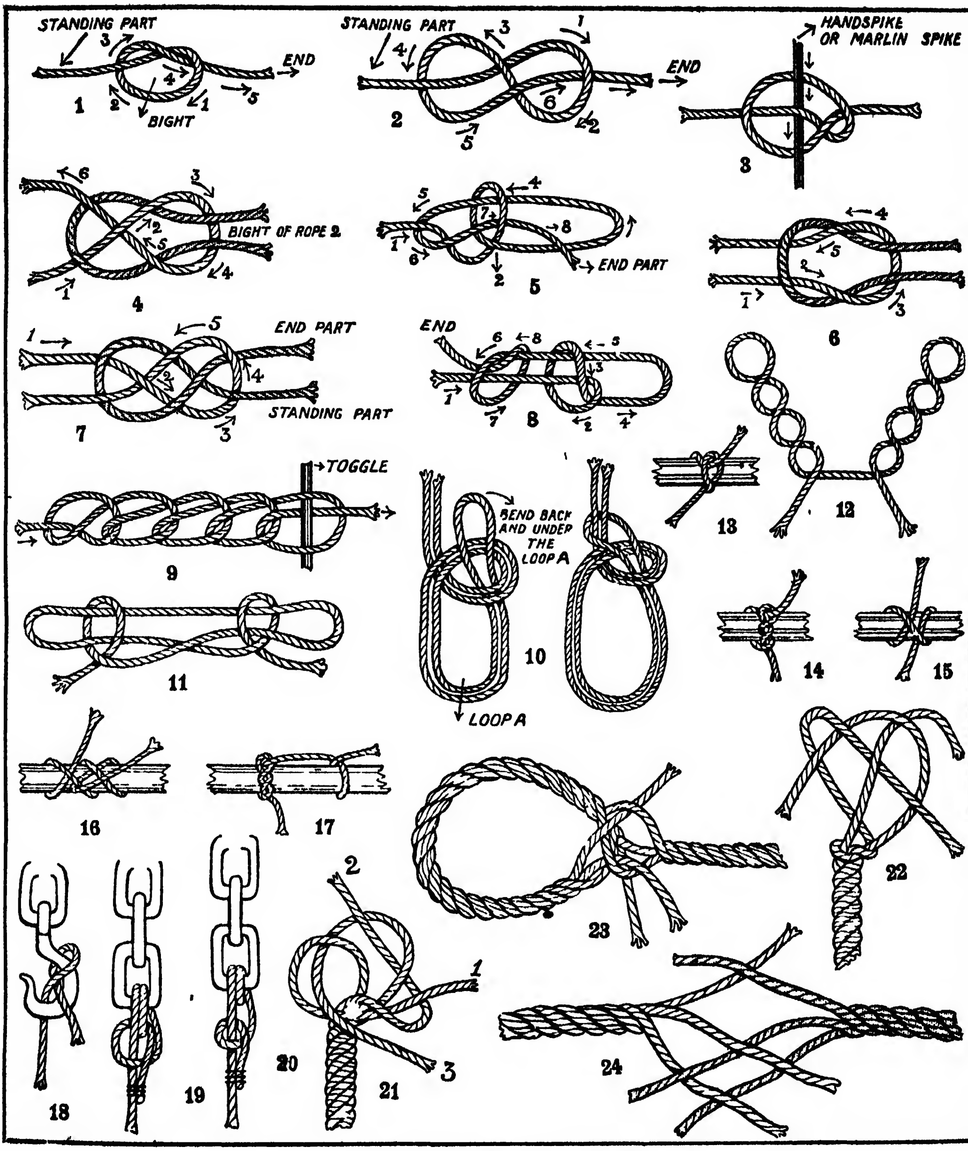
TIMBER HITCH [14]. Similar to above, but reeve several times round its own part.

CLOVE HITCH [15]. Pass the end round the spar, crossing the standing part. Then pass round spar again, and bring end through between the end part and standing part, under its own part.

ROLLING HITCH [16]. Pass end twice round spar, crossing standing part each time. Then hitch end round the spar on the opposite side to the two turns.

TIMBER AND HALF HITCH [17]. Make half hitch first, and then make a timber hitch with the end part.

BLACKWALL HITCH [18]. This is used for suspending cargo from a crane hook. Pass the end round the back of the hook, and under its own part, taking care that the two parts of the rope are on opposite sides of the hook.



SAILORS' KNOTS AND HITCHES

1. Overhand knot 2. Figure of eight 3. Handspike hitch 4. Sheet or common bend 5. Common bowline 6. Reef knot 7. Carrick bend 8. Flemish loop 9. Chain knot and toggle 10. Bowline on a bight 11 Sheepshank 12. Catspaw 13. Half hitch 14 Timber hitch 15. Clove hitch 16. Rolling hitch 17. Timber and half hitch 18. Blackwall hitch 19. Fisherman's bend 20. Round turn and half hitch 21. Wall knot 22. Crown knot 23. Eye splice 24. Crutching or marrying a splice

FISHERMAN'S BEND [19]. This is used for fastening a cable to a shackle or ring. Pass the rope twice round the ring, and put the end through the turns. For security the end must be tied to the standing part with fine cord, or "stopped back," as the proper term is.

ROUND TURN AND HALF HITCH [20]. Used for the same purpose. Pass end twice round the ring, and make half hitch round standing part. Stop end back to standing part.

WALL KNOT [21]. This is a neat method for finishing off ropes, and preventing them from unlaying. It is made in two stages, as follows:

(1) Untwist the three strands of the rope for a distance sufficient to give you three cords about eight inches long each. Call these strands, 1, 2, and 3. Make a bight with strand 1 and pass 2 round the end of it. Then pass strand 3 round end of 2 and through bight of 1.

(2) Haul ends taut, shaping the knot evenly with the fingers.

CROWN KNOT [22]. This is a further completion of the wall. Make wall and then take strand 1 over centre of wall. Place strand 2 over 1 and 3 over 2, and under 1; pull these taut. Shaping with fingers is necessary, and the crown is complete.

With a sound knowledge of these knots the sailor will be able to make his way as far as knotting is concerned; but to join ropes permanently he must be able to splice, which we shall now explain.

Splicing. Splicing is the art of interlacing the strands of ropes so as to make them practically

one cord. To separate the strands a marlinspike, which is an exaggerated steel needle, is necessary.

Eye Splice. This [23] is the method of making a permanent loop at the end of a rope. Take the end of the rope and unlay the three strands for about 4 in. Then place these against the standing part at the spot which will give a loop of the desired size. Take the middle strand and after prising up one of the strands of the standing part pass the free strand beneath it. Pass the other two strands, one on each side, under the other strands of the standing part, and work the loop up tight. Slightly taper the strands, by pulling off a little of the hemp (the usual practice is to cut one or more of the yarns composing the strands of the rope), after first tuck has been completed with all strands, and pass them under the strands of the standing part again, taking care that each free strand passes over one of the standing strands before entering beneath the next strand. The ends are now again further tapered and the process repeated a third time. All ends are now clipped off short, after the splice has been well hammered, and then fine spunyarn is bound round the joint. Binding with spunyarn when done the reverse way to the lay of the rope is called *serving*.

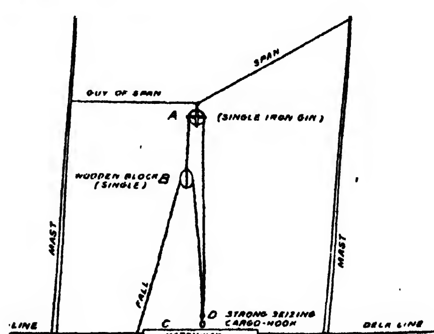
Short Splice. To make a short splice, or join between two ropes, the ends of each must be unlayed, or unravelled for a few inches. Then fit the ends of each rope accurately together, so that the ends of one lie between the ends of the other. This is called *crutching* or *marrying* the ropes [**24**]. Now pass each strand over one strand of the opposite rope and tuck it under the next strand. When this has been done once with each strand of each rope, taper the ends a little and repeat the process a second time. Clip off the ends, and if necessary serve with spunyarn.

Long Splice. This is used where no increase in the circumference of the rope is required. To begin with, each rope must be unlayed about three times further than for a short splice. Then the parts are married. Now take one of the strands of the right-hand rope and unlay it still further, filling up the groove thus made with the corresponding strand of the left-hand rope. This must be done till only a short end of the left-hand strand remains free. Repeat the operation on the left-hand rope, filling up with the corresponding right-hand strand. You will now have two long strands in the middle, and at some distance on each side of them there will be a very long strand and a very short one. Deal with each of these three points separately. Divide the strands at each point and tie the corresponding divisions together. Then take the ends at each point thus formed and tuck them under the second strand, having passed over the first one. Taper the ends and tuck them a second time over a strand and under the second from it. Hammer and stretch the rope well and cut off all loose ends.

Worming and Parcelling. *Worming* is filling in the grooves of a rope with spunyarn so as to make the surface absolutely smooth, and to prevent water from reaching the heart of the rope. It must be done in the direction of the lay of the rope. *Parcelling* is bandaging the rope with strips of tarred or oiled canvas about two or more inches wide, according to size of the rope dealt with. This must be done with the lay of the rope, and each lap must overlay the one prior to it. In parcelling rigging, parcel from below upwards, so that the overlays shed the water. Serving is done against the lay, as we have indicated. The rule is easily remembered:

" Worm or parcel with the lay,
Turn and serve the other way."

Purchases and Tackles. For lifting heavy weight, and obtaining increased power for hauling on the various ropes in a ship a number of combinations of blocks and ropes are used. The simplest is a *single whip*, which consists of a single pulley over which the rope runs. The pulley is made fast to a spar or to some portion of the rigging. Next comes a *double whip*. One end of the rope is made fast to a spar or the rigging, the other passes through a block fitted with a hook on which the weight is to be lifted. The rope then runs up and through a second block fastened to the spar or rigging beside the end of the rope, and thence to the winch or to the men who are to haul. A *gun tackle* is similar, save that the end of the rope is fastened to the second pulley, and there is, therefore, only one point of attachment to the spar. A *luff tackle* has a double-wheeled pulley at the top, and a single pulley with a hook at the bottom to attach to the cargo or sheet. The rope is fixed to the single pulley, runs up through one wheel of the double block, then down and round the wheel of the single pulley; up again, then round the second wheel of the double block and thence to the men or the winch. A *runner and tackle* is simply a luff tackle, the top block of which is suspended from a single whip. A *fourfold purchase* has a double block at the bottom as well as at the top. The rope is attached to the top block and passes twice through the pulley holes of each before being led to the winch. It is a very powerful purchase indeed. A *long tackle* differs from the previous purchase only in being made of two single blocks strapped end to end at each end in place of a double block. The rope is attached to the lower of the upper two blocks, passes through the upper of the two under blocks, through the lower of the two upper, then to the lower of the lower pair, and finally over the upper of the upper pair. A Spanish Burton is a useful tackle for lowering weights (cargo) into a vessel's hold and is almost solely used for that purpose. It consists of two blocks, one cargo-hook and a long rope (fall), and can best be explained by the annexed sketch [25].



25. SPANISH BURTON

In reeving this purchase it is necessary to know the distance from position of block A (which is generally secured to a span stretched between vessel's masts in such a manner as to be vertical over a hatchway) to the bottom of vessel's hold, in

order that the block B may not touch the upper block A before the weight attached to cargo-hook C has reached the bottom of hold. The two parts of the tackle-fall are strongly seized together at point D after its being rove through the eye of said cargo-hook and holding same in desired position.

A few days at sea will suffice to teach the would-be sailor the names and uses of the various parts of the ship, of the standing and running rigging, and we will at once give a few rigging details which the sailor may well have to perform at sea.

To Send a Topmast Down. The same instructions apply to a topgallant mast. Reeve the mast rope through a block at the lowermost head, through the sheave hole in the heel of the mast, and make it fast at the other side of the mast-head. Come up all the gear, back stays, rigging and stays, sway a little and then get the fid out. Then lower away and surge quickly just before the crosstrees come on the lowermost head. Send down all the gear with gantlines, or auxiliary ropes rove through blocks. Single the mast rope and lower the mast on deck.

To Send a Topmast Up. The same instructions apply to a topgallant mast. Lay mast on deck, after side up, and heel aft. Hook a block to eyebolt at one side of the cap, and reeve the mast rope from aft, down through the square hole in the trestle trees, along the mast, and through the sheave hole at the heel of the mast.

Bring it back along the mast, and hitch it round the masthead and the standing part of itself, leaving enough end for doubling. Rack the two parts together below the hitch. Now hoist away and point the head of the mast through the hole in the trestle trees. As soon as it is through, cast the hitch adrift and double the mast rope by taking end up through trestle trees, making it fast at the other side of the cap. Come up (slacken and let go) the racking and hoist away again, until the masthead is a few feet above the cap, and then lash gantline blocks to the topmast head, reeving the gantlines from forward and overhauling them down to the deck; bend them to the after crosstree legs and stop them to the fore; hoist away till you can rest them with the after part resting on the lower masthead, fore part against the topmast, and underside forward. Cut the stops, and the crosstrees will fall over the masthead, then heave away till the crosstrees are in their proper place. Next put on the gear of the mast; for a topmast, first the bolsters, then starboard rigging, next port rigging, starboard backstays, port backstays, and topmast stay last of all; for a topgallant mast, first the funnel or grummet, then the topgallant stay, next rigging (starboard side first), and last the backstays. A royal mast is rigged the same as a topgallant mast. In topgallant and royal mast riggings, the gear is put over the masthead as soon as the mast is pointed through the topmast cap. This done, the mast rope is hauled upon and the mast placed in position and fastened by a fid, or otherwise, according to the mast. All rigging is then tightened up and made fast.

Sending Down Yards in a Gale. These directions are for topsail yards, and for all above them; those for main or fore yards will follow. In smooth weather, such great precautions need not be taken, but it is well always to remember the sailor's proverb: "Better be sure than sorry." First unreeve the tie and reeve the yard rove through sheave hole at the masthead. Take a hitch round the lee quarter, and make the end fast to the weather quarter of the yard. Clear the yard of buntlines, clewlines, and leechlines, and of foot-ropes from the after side of the mast. Lash a preventer parral round yard and mast to keep the former close to the latter, till all is ready for lowering. Now sway away a little, and so take away the strain off the lifts. Unparral the yard, leaving the preventer parral. Take the lifts off; top the yard and stop the yard rope to the lee yardarm. Cast off preventer parral, and lower away abaft all and to windward, sliding down the other part of the yard rope, or steadying the yard as she comes down with a tripping rope. The braces are taken off as the yard comes down. When a yard is very heavy, a double purchase must be used.

Sending Down Main and Fore Yards. These, being very heavy and very long, have to be lowered athwart ship. A powerful purchase is made fast to the centre of the yard, suspended from the lowermast head, or the topmast head. At each arm a guy rope is fixed to keep the yard level as it comes down, and from the centre a whip is rove through a block on the fore side and led well forward. The purchase is hauled upon, and then the sling is unshackled and the truss unfastened. Then lower away, steadying the yard with the guys and keeping it close to the mast by the forward whip. To send up a fore or main yard, reverse the above proceedings exactly.

To Send Up a Topgallant or Top-Gallant Yard. Reeve the yard rope, abaft everything and to windward, through the sheave hole at the masthead; overhaul down to the deck and make fast about the middle of the yard, and stop it to what will become the lee yardarm. Put all gear on the yard, except the braces. Heave away, and when high enough, shackle on the braces. Cast off the lee yardarm stop when the centre is high enough. Put on the lifts and parral the yard. Let the yard take the lifts and haul on the braces. Then reeve the halyards and any other gear. For heavy yards, a purchase must be used instead of the simple yard rope rove through the masthead sheave hole.

Remember that all yards that hoist are supported by parral, lifts, and halyards, the lifts and halyards taking the weight when the yard is down, and the halyards when the yard is up. Fixed yards, such as fore, main, crossjack, lower topsail, and lower topgallant yards, are trussed.

To Send a Jibboom Out. Reeve a haul rope through a block at the cap of the bowsprit, through the heel of the boom, and make fast to the bowsprit cap on the other side. Overhaul fore and aft stays, back ropes, and guys; make flying jib halyards fast to end of boom, to keep it from tripping. Heave away till boom is far enough out, then down with the heel. Clamp it and lash preventer round boom and bowsprit.

To Send Jibboom In. Reeve heel rope as before, and slacken all gear. Make flying jib halyards fast to end of boom, and heave a little to get the heel clear. Get tackle on to heel and haul into place.

Reducing and Setting Sail. The order in which the square sails of a ship are usually set is as follows: Lower main topsail, lower fore topsail, lower mizzen topsail, foresail, crossjack, main upper topsail, mainsail, fore upper topsail, mizzen upper topsail, main, fore, and mizzen topgallant sails, main fore and mizzen royals. In some ships the crossjack is not set till after the mainsail. When reducing sails, the general practice is to take them in in the reverse order to setting them. The staysails are set

and taken in in no regular order. They are very useful in keeping steerage way on a ship, and in keeping her on her course; and the officer of the watch generally tries to keep at least one set. Here is practical example of taking in a setting sail, taken from "Reed's Seamanship."

"In a full-rigged ship, the wind begins to get up. The officer first takes in royals, flying jib, small staysails. The wind increases and all topgallant sails are stowed. As it gets worse, each topsail is reefed. If the wind gets worse, the fore and mizzen topsails are close reefed, or where a ship carries double topsails, the upper ones are stowed, the courses are reefed, and the mizzen taken in. As the gale gains power and the sea gets up, everything is stowed but the three lower topsails, the reefed foresail, and the fore topmast staysail. These would be kept set as long as the ship could stand it; then the sails would be reduced to two lower topsails, and if these could not stand, they would be taken in, the fore one first, and a storm sail set. If possible, the royal and topgallant yards would be sent down before the gale reached its height. Should the storm staysail blow away, a tarpaulin would be lashed in the rigging to take its place.

"The weather moderates, and the three lower topsails are set, with the reefed foresail and the fore topmast staysail. As it improves, the three upper topsails would follow, and then the jib and lower staysails. Next, the mainsail and mizzen or crossjack. After that, all reefs would be shaken out, and lastly the topgallant sails and royals would be added, with any staysails that had not been set."

Tacking, or Putting Ship About. First give the order "About Ship." See that all is clear, and the hands at their proper stations. Ease the helm down and haul the mizzen boom amidships. Order "Helm-a-lee." Watch, and as she comes to, and shakes, give order "Tacks and Sheets." When she comes within one point of the wind, give order, "Mainsail Haul." Down main tack and aft sheet. Trim the head sheets and shift helm, if necessary, to bring her round. When round enough for the head yards to fill—that is, when the mainsail is full, and it seems likely that the foresail will fill—give order "Let go and Haul"; down tack and aft sheet of foresail, brace yards, and haul out bowlines, and the ship is on her new course. If she will not come round, and gathers much sternway, then she has "missed stays," and you must bring her round on her heel. Shift the helm a-lee again, square after yards, haul head sheets aft, and brail in the mizzen. When she gathers headway, shift helm a-weather and keep her so till the after yards shiver. When before the wind, square the fore yards, and as soon as the wind comes to the other quarter, haul out the mizzen and brace the yards up as the ship comes on her new course.

To wear an ordinary ship, brail in the mizzen, hard up the helm, and as she goes off, square the after yards, keeping them just shaking. When before the wind, square fore yards and brace up for the other tack. As soon as the ship begins to come to, brace up after yards and set mizzen.

Setting and Taking in Sails. Instructions for setting and taking in sails are as follow:

TO SET A COURSE. Courses are the lower sails. Loose the sail, overhaul all gear, let go lifts, haul aft the slack of the sheet, down with the tack, and haul the sheet flat aft.

TO TAKE IN A COURSE. Keep ship well full, steady the lifts, ease off the lee sheet a little; man weather clew garnet, buntlines and leechlines; ease away tack and haul on clew garnet, and buntlines. The tack being close up, man lee clew garnet, buntlines and leechlines, ease away the sheet, and haul upon clew garnet, buntlines and leechlines. Then stow the sail.

TO SET A TOPGALLANT SAIL, ROYAL OR SINGLE TOPSAIL. Loose the sail, overhaul the gear, haul home the lee sheet, then the weather sheet. Hoist the yard tending the weather brace, and haul tight the lee brace.

TO TAKE IN THE SAME. Clew down the yard, check the weather brace, haul up the lee clew line, bunt line and leech line. Then the same on the weather side and stow the sail.

TO SET UPPER TOPSAIL OR UPPER TOPGALLANT SAIL. Loose the sail; let go the downhauls and sheets of the sail above. Overhaul the gear, and hoist away on the halyards, tending the weather brace.

TO TAKE IN THE SAME. Lower away, haul on the downhauls, take in slack of weather brace, haul on the buntlines; steady tight the halyards, and braces, placing the yard parallel with the lower yard, and then stow the sail.

TO SET THE MIZZEN. Ease off the weather vang and boom sheet; let go the brails, haul on the foot outhaul, and then on head outhaul, and when the head is full out tauten up everything, and trim sail.

TO TAKE IN THE SAME. Ease off weather vang and boom sheet, haul down the head, slack away the foot outhaul, and haul on the lee brails, taking in the slack of the weather brails.

TO SET A JIB. Loose the sail, haul sheet aft, let go downhaul, and hoist away on halyards, tending the sheet, and when set trim.

TO REEF AN UPPER SAIL. Lower the yard, haul in the weather brace, and check the lower yard; haul out the reef tackles, if any, steady tight the halyards and lay aloft. Haul out the earings and tie the points, slack away the reef tackles, let go lee brace, and hoist yard, tending the weather brace as yard goes up.

TO REEF A COURSE. Hook a reef pennant on to the weather clew and haul tight the lifts. Haul sail up the same as for stowing, but not quite so high, then haul out reef tackles. Lay aloft. Haul out earings and tie the points. Slack away reef tackles and set sail again.

TO SHAKE OUT A REEF. Haul reef tackles well tight. For a course ease tack and sheet, for an upper sail settle the halyards and haul tight the downhauls. Lay aloft. Each man begins untying points at the middle of the yard and works outwards. The earings are eased off together, reef tackles let go and sail set.

The Rule of the Road. This is one of the most trying branches of seamanship, and one which can be learnt from books. Vessels at night carry a red light on the port side, and a green light on the starboard side. Steamers also have a white light some distance up the foremast. Now, the primary rule is that *all* vessels overtaking another have to keep clear of the one they are overtaking. With this sole exception, all steamers under way have to keep clear of every sailing vessel.

The most common case is that of two steamships meeting. If they are end on—that is, when each can see all three lights of the other—then each has to alter her course to starboard.

> When all three lights you see ahead,
> Port your helm, and show your red.

If two steamships are meeting, but are passing clear of each other on the starboard side, the green light of the other vessel's starboard light will be seen, or on the port side, the red light. By day, it is easy enough to see whether the vessels are in the proper position for safety. The rule can be remembered by:

> Green to green, or red to red, perfect safety—go ahead.

When two steam vessels are crossing, the vessel which has the other on her starboard side shall keep out of the way of the other. That is to say, that if a steamer is crossing you coming towards your starboard side, or at night you see her red light, then you have to keep clear; if she is coming the other way, she has to keep clear of you. The fixed rule is thus memorised:

> If to my starboard, red appear,
> It is my duty to keep clear;
> To act as judgment says is proper:
> To port, or starboard, back or stop her.
> But when upon my port is seen
> A steamer's starboard light of green,
> There's naught for me to do but see
> That green to port keeps clear of me.

In the event of the light appearing very close up, both vessels must do what judgment suggests.

Sailing Ships Meeting. When two sailing ships are meeting, or liable to cross, the following rules have to be observed:

1. A vessel which is running free—that is, with the wind on the beam, or abaft it—must keep out of the way of a vessel which is close-hauled.
2. A vessel which is close-hauled on the port tack must keep out of the way of a vessel which is close-hauled on the starboard tack.
3. When both are running free, with the wind on different sides, the vessel which has the wind on the port side shall keep out of the way of the other.
4. When both are running free, with the wind on the same side, the vessel which is to windward shall keep out of the way of the vessel to leeward.
5. A vessel which has the wind aft shall keep out of the way of the other vessel.

Every vessel which is directed to keep out of the way shall avoid crossing ahead of the oncoming vessel if such is possible.

Vessels which are being overtaken at night shall show a white flare over their stern, as a warning to the oncoming vessel.

Direction at Night. To tell at night the direction a vessel is steering, the rule is as follows:

FOR STEAMSHIPS APPROACHING. If a green light is seen, take the bearing and the vessel will be steering between six points to the right of that bearing and the opposite point of the bearing nearly. If she was steering exactly to the opposite point of the bearing, all her lights would be seen. If a red light is seen, the direction will be between six points to the left of its bearing, and the opposite point of the bearing nearly.

FOR SAILING VESSELS. The same rules apply, but you must also take the direction of the wind, and remember that very few sailing ships can sail within six points of the wind, so all directions which lie within six points of the wind have to be eliminated. For instance, with the wind north, a sailing ship's red light is seen bearing due south. She must be steering between E.S.E. and E.N.E., because, though the rule gives you between E.S.E. and north as her direction, she could not sail between E.N.E. and north, because E.N.E. is six points from the wind.

Lights and Signals

Steamships under way carry	White masthead light, green and red side lights. Some have second masthead light.
Vessels under oars or sails, less than 20 tons burden.	Have ready red and green hand lamp, or a lantern showing white light.
Steamships towing.	Two white masthead lights vertical, 6 ft. apart. Red and green side lights. If towing more than one vessel, or if tow be more than 600 ft. long, then an extra light must be shown.
All vessels not under command.	Night. Two red lights, vertical, 6 ft. apart. Day: Two black balls or shapes in same position. If making way at night, side lights as usual.
Telegraph ships.	Night: Three lights, red, white, red, vertical, 6 ft. apart. If making way, side lights as usual. Day: Red ball, white diamond, red ball in same positions.
Sailing vessels under way, or any vessel being towed.	Red and green side lights.
Open fishing boats under way.	Lantern with red and green sides.
Vessels at anchor.	White light visible all round horizon. If over 150 ft. long, two white lights, forward one at least 20 ft. above hull, and after one 15 ft. below forward light.
Vessel aground.	Lights for anchored vessel and for a vessel not under command.
Sailing pilot vessels.	White masthead light, and flare up at intervals of not more than 15 minutes. Also side lights at short intervals.
Steam pilot vessels.	White masthead light, and red below it. Side lights, and flare when anchored, masthead lights and white flare as above, but no side lights.
Vessels drift net and line fishing.	Two bright lights, visible all round horizon, where best seen. Flare at approach of other vessels.
Steam vessels trawling.	Same as other steamers under way, or red and green lights to show four points abaft the beam.
Sailing vessels trawling.	Masthead lantern with red and green lights showing over 12 points each, and between 6 ft. and 12 ft. below them a white light. Or same as ships under way.
Light vessels out of place, and so useless for navigating by.	Night: Red light forward, and similar light aft. Day: All distinguishing marks struck, and red flags fore and aft.

In thick weather vessels are required to keep a foghorn or syren sounding at regular intervals when under way, and to ring the ship's bell every minute when not moving.

Warning Signals. The Morse code can be utilised for warning signals, either by giving blasts on the foghorn or by flashes of a lamp. Short blasts and flashes are of one second's duration; long blasts or flashes are three seconds in length. Between each flash or sound, a second should be allowed to elapse. Morse alphabet, as used in telegraphy, has been given on page 4382. When used in ship signalling, dashes are long flashes or blasts, and dots are short ones.

Special signals are as follow:

Preparatory signal to attract attention . . . . etc.
Answering signal. I understand — . — . — . — . etc.
You are standing into danger . . —
I want assistance. Stand by me . . . —
Have met ice . — —
Your lights are out or bad . — — .
Way off my ship. Come past carefully . — .
Stop; I have something to communicate . — . .
Am disabled; communicate with me . . — .

BETWEEN VESSELS TOWING: Steer more to starboard . Steer more to port . . Cast off hawsers . . . .

Pilot Signals. By Day: (1) Union Jack, with a white border, at the foremast; (2) International Code Pilot Signal PT; (3) International Code S, with or without pennant over it; (4) Distant signal, consisting of cone, point upwards, having above it two balls or shapes like balls.

By Night: (1) Blue light firework every 15 minutes; (2) bright, white light just above bulwarks shown for a minute at a time, constantly repeated.

Signals of Distress. Distant signal of cone, point upwards, and above or below it a ball or a bundle resembling a ball.

Morse Code V.

A flare-up or any detonating signal, or a burning tar barrel on deck, or rockets.

International Code Signals. These are made with coloured flags, as given below. The ordinary signals will be found in the "International Code of Signals," a book which every ship carries. The names of vessels will be found in the British "Code List," which is also found on most ships, and is supposed to be carried by all. The flags are as follow:

A = A burgee, half white, half blue. White next the mast.
B = A red burgee. Also signifies carrying powder.
C = A white pennant with a red spot in centre. Alone means "Yes."

D = A blue pennant with white spot in centre. Alone means "No."
E = A red, white, and blue vertically striped pennant. Red next mast.
F = A red pennant with white St. George's cross on it.
G = A yellow and blue pennant, divided vertically in half. Yellow next mast.
H = A square flag, half red, half white, vertically. Red next mast.
I = A yellow flag with blue spot in centre.
J = A flag striped horizontally blue, white, blue. Three stripes only.
K = A yellow and blue flag, halved vertically. Yellow next mast.
L = A flag quartered yellow and black. Alone means cholera on board.
M = A blue flag with white St. Andrew's cross.
N = A blue and white chessboard pattern flag. Sixteen squares.
O = A red and yellow flag divided diagonally in half. Yellow next mast.
P = A blue flag with white square in centre. Means "Am putting to sea."
Q = A yellow flag. Means "Am in quarantine."
R = A red flag with yellow St. George's cross.
S = A white flag with a blue square in centre. Means "Pilot wanted."
T = A red, white, and blue flag. Red next mast.
U = A flag quartered red and white. Quarterings vertical.
V = A white flag with red St. Andrew's cross.
W = A red, white, and blue flag; red in centre, white round and blue round that again.
X = A white flag with blue St. George's cross.
Y = A flag striped yellow and red diagonally. Ten stripes.
Z = A flag quartered diagonally. Top quarter yellow. Bottom quarter red; quarter next mast black, outside quarter blue.

CODE PENNANT. A pennant striped red and white, five stripes. Red next the mast.

Urgent and important signals are either one or two-flag signals, and will be found on pages 10 to 19 of the "International Code of Signals," which we shall call the "Signal Book." Three-flag signals are either compass signals in degrees and points, on pages 20 and 21; money, on pages 22 to 25; measures and weights, pages 26 to 31; fractions and decimals on page 32; metrical weights and measures, pages 32 and 33: auxiliary short phrases, on pages 34 to 63, or are general vocabulary on pages 64 to 414. Four-flag signals are geographical signals, on pages 422 to 515; alphabetical spelling, pages 516 to 534, or are names of vessels. These last will be found in the "British Code List." The names of men-of-war have the G pennant uppermost; merchant ships have a square flag uppermost. When a ship is signalling, you must keep the code pennant, or *answering pennant*, as it is called, hoisted as long as you understand. If you do not understand the signal, then dip the pennant, and it will be repeated. While waiting between signals, keep the pennant at the dip.

Distant Signalling. When you wish to make a signal, and the ship or point you wish to communicate with is too far away for the colours of the flags to be distinguished, you must use the distant signals, which run as follow:

Four signs are used, namely, a cone, point upwards, which we will call 1; a ball, which we will call 2; a cone, point downwards, called 3; and a square, which we call 4. The following alphabet must be read as follows: The first number given as at the top of the mast; the second just below it, and so on. Distant signals are only three-sign signals.

A = 1.1.2.	J = 2.1.3.	S = 2.4.1.
B = 1.2.1.	K = 2.1.4.	T = 2.4.2.
C = 1.2.2.	L = 2.2.1.	U = 2.4.3.
D = 1.2.3.	M = 2.2.3.	V = 3.1.2.
E = 1.2.4.	N = 2.2.4.	W = 3.2.1.
F = 1.3.2.	O = 2.3.1.	X = 3.2.2.
G = 1.4.2.	P = 2.3.2.	Y = 3.2.3.
H = 2.1.1.	Q = 2.3.3.	Z = 3.2.4.
I = 2.1.2.	R = 2.3.4.	

Code flag sign, 4.2.1. Alphabetical sign, 4.2.2. Numerals, 4.2.3. End of word or number, 4.3.2.

With these signals, any of the methods given in Signal Book can be used, the distant signs being hoisted instead of the flags, only, of course, the equivalent of each flag must be hoisted separately, and when the end of each hoist of flags is reached, 4.3.2. is sent up.

Law of Storms. The ordinary casual storm which we know in this country is also found at sea. It is not a storm following any specific course, and so is not liable to be reduced to rule. The revolving storms, or cyclones, which are really dangerous, follow definite rules. The first point of importance when a cyclone is met is to be able to determine the probable bearing of its centre. This is done by the following rule:

Take the direction of the wind, and in the northern hemisphere, from 12 to 8 points to the right of the direction of the wind for the probable bearing of the centre. In the southern hemisphere, allow from 12 to 8 points to the left of the direction of the wind for the probable centre. These points are allowed as follows: At the beginning of the storm allow 12 points; when the barometer has fallen three-tenths of an inch allow only 10 points; and when the fall is six-tenths, or more, allow about 8 points for the centre.

If during the cyclone the wind changes towards the right, then the ship is on the right hand of the line of progression: if to the left, it is on the left of the line. In the northern hemisphere, in the first case, it is advisable to heave to on the starboard tack; in the second case, run with the wind on starboard quarter, or, if compelled, heave to on the port tack. In the southern hemisphere this would be reversed; with the ship to the right of the line of progression, run with the wind on the port quarter, or, if compelled, heave to on the starboard tack; with the ship to the left of the track, heave to on the port tack. If the wind does not change, run with the wind on the starboard quarter in the northern hemisphere, and run with it on the port quarter in the southern hemisphere, till the barometer has ceased falling.

When the ship is in the line of progression of the centre of a cyclone, the wind does not shift, but the barometer falls rapidly and the sea increases. When the barometer falls rapidly and steadily, the wind and sea increase, and the wind shifts about fitfully, then the ship is approaching the centre of the cyclone; the opposite conditions mark departure from the centre of the storm.

Storm Tracks. The following are the principal tracks taken by cyclones:

IN THE NORTH ATLANTIC. Storms begin generally in lat. 8 to lat. 20 N., travelling to the W.N.W. and N.W., and when in about lat. 30, to the N., N.E., and E.N.E., gradually increasing in diameter, but getting less violent as they expand. They occur most frequently from July to October.

BAY OF BENGAL. The track runs westerly to north-westerly during May, June, October, November, and December.

THE CHINA SEAS. Cyclones run westerly to north-westerly in July and August, and south westerly to north-westerly from Sept. to Nov.

INDIAN OCEAN. Cyclones begin generally in lat. 8 to 20 S., travelling to W.S.W. and S.W., and when in 30 S. change to S., S.E., and E.S.E. in direction. They expand after that rapidly, and blow themselves out. They are most frequent from January to April.

Continued

A SHORT DICTIONARY OF NAUTICAL TERMS

A.B.—Able (bodied) seaman.
Aback—Wind striking forward side of sails.
Abaft—Nearer the stern.
Abeam—Abreast ship; in the distance at right angles to the keel.
Aboard—Upon or in a vessel.
Aboutship—Tack, or turn head of ship to wind, so that the lee side becomes the weather or windward side.
Ahead—Object in advance of a vessel.
Aloft—Above deck, in rigging.
Astern—Behind.
Athwart—Across.
Avast—Stop.

BACK A SAIL—Let wind press on fore side of sails to stop ship's way.
Backstay—Rope supporting upper mast, secured to gunwale abaft same.
Batten down—Fasten down all hatchways by means of covers or tarpaulins.
Beam—Extreme width.
Beam ends—When a ship lies on her side so far as to be unmanageable.
Bear up or away—Steer for desired point or destination.
Bearing—Direction.
Beating — Zigzag progressing of a sailing vessel against head wind.
Belay—To secure a rope.
Bells—Half hours of a watch struck on ship's bell.
Bend—To fasten; sails are bent to yards or to stays.
Bight—A loop in a rope; the middle of a slack rope suspended horizontally.
Bilge—A channel at bottom of ship each side; the union of the flat of a vessel's bottom with its sides.
Bitts—Appliance constructed of wood or hollow cast iron fastened to upper deck or rails, for the belaying of hawsers, warps, etc.
Block—A pulley.
"Blue pigeon"—Seaman's term for hand and deep sea lead.
Bollards—see *bitts*.
Bolt rope—A rope of superior quality to which the canvas for sails is attached.
Booms—Spars of light character.
Bow—The fore end of a vessel.
Bowers—The principal anchors.
Bowline—A rope to bow leech of sail forwards; a knot; "to sail on a bowline"; to sail close to the wind.
Box—To "back" all foresails; to name the 32 points of the compass.
Braces—Ropes from yardarms by which sails are trimed.
Brace up—Haul yards further forward.
Brail up—Take in sails attached to masts by the brails.
Break bulk—Commence discharging cargo.
Bring to—To stop a ship by anchor or sail.
Broach to—To come to the wind against the helm.
Bulkhead—Partitions of wood or iron by which compartments are formed; or transverse water-tight divisions in vessel's hold, usually constructed of steel or iron plating.
Bunk—Seaman's bed on board ship.
Bunt—Middle of furled sail; buntline ropes from foot of sail to haul it up.
Bunting—Light fabric of which flags are made.

CABLE-LAID—A rope of nine strands.
Cant—To turn over.
Cap—Fitting joining upper and lower masts.
Capstan—A vertical winch worked by steam or by capstan bars.
Careen—To heel over till part of bottom is out of water.
Cast off—To let go.
Cat block and fall—Large block and rope for hoisting anchor.
Cathead—Projecting piece of timber on each bow. It is fitted with sheave holes, through which a purchase, called a cat-fall, is rove for hoisting anchor from hawse pipe to cathead.
Chain-hooks—Iron rods about three feet in length, hook-shaped at one end, for handling cables or other chains.
Chain-locker—A trunk made of wood or iron, usually situated underneath the windlass, and extending from deck to keelson, used for stowing chain cables.
Chain plate—Iron plate fastening deadeyes of rigging to gunwales.
Cleat—Appliance used in belaying; piece of wood to reeve anything through.
Clew of sail—Corner to which sheet is attached.
Clew line—Ropes for hauling up clews of square sails.
Clew garnet—Ropes for hauling up clews of square sails and courses.
Clew-up—To haul up square sails to yards by attached gear (ropes).
Club haul—To tack by letting go and then slipping the hawser attached to an anchor.
Coamings—Frame of hatchways extending above level of deck.
Courses—Foresail and mainsail and crossjack of square-rigged vessels.
Crank—Top heavy, easily heeled over on to side.
Crosstress—Spreaders on masts to support topgallant rigging.

DAVIT — A crane to lift boats or anchors.
Deadeye—A block of wood with three plain holes; a rigging frame.
Deadlight—Cover or shutter, fitted to protect the glass of a skylight or sidelight during stormy weather.
Derrick—A spar of wood or iron held by guys and topping lifts for lifting weights.
Dog Watches—From 4 to 6 and 6 to 8 p.m.
Downhaul—Rope attached to headcringle of fore-and-aft sails for furling same.
Drag—An anchor not holding drags.
Draught — Depth of ship's immersed surface below waterline.
Draw—When sail takes the wind properly.
Draw-bucket — Appliance made of canvas in the shape of a bag, with a strong hoop fitted to keep the mouth of same open, to which a rope lanyard is attached, used for drawing water from over side.
Driving—Dragging anchor in gale or tideway.
Drop of sail—Distance from foot to yard.
Dunnage — Odd wood placed in stowage of cargo as required.

EARINGS—Upper corners of square sails and ropes fastening them.
Ease helm—Move it more amidships.
Ease her—Go slow.
Ease off—Slacken rope.
Even keel—Drawing same water fore and aft.

FAIRWAY—Free passage to or from harbour; deepest channel.
Fall—Part of a tackle hauled upon.
Fill—To make sail take wind.
Fish—Strengthening piece of wood or iron.
Fish davits, blocks, fall, etc.—Crane and tackle for hoisting flukes of anchor.
Flatten sail—To make it taut.
Flowing sheet—Sheet eased off to fair wind.
Foot-ropes—Ropes below yards on which sailors stand; rope attached to lower side of sails.
Fore and aft—Lengthways of keel.
Forecastle—Forward part of upper deck. Sailors' quarters (generally).
Foul—Entangled, contrary, dirty.
Freeboard—Distance between deck and waterline.
Furl—To roll up square sails and secure to yards. Others are stowed or made fast.

GAFF—Small spar abaft a mast to which the head of a fore-and-aft sail is bent.
Galley—Cooking place on board ship.
Gangway—Entrance to ship. Narrow passages fore and aft. If under bridge or upper deck, called "alleyways."
Gantline—Small rope rove through single block, used for lifting or lowering purposes.
Garboard—Lowermost strake of outside plating, and connected to the keel.
Gaskets—Plaited bands, generally small manilla rope, to secure furled sails.
Ground-tackle—Term applied to a vessel's anchors and cables.
Guys—Ropes to keep small spars in position.
Gybe—To let fore-and-aft sail shift from side to side by action of wind changing from quarter (of ship) to quarter.

HALYARDS—Ropes for hoisting sails.
Hard down or hard a lee—Position of helm the reverse of hard up; command given in tacking ship.
Harness casks — Teak wood barrels of peculiar shape for holding salt beef and pork for immediate use.
Haul up—Alter course to windward; to furl a sail.
Hawse holes, pipes, etc.—Part of ship through which anchor cables run.
Headsails—Jibs and fore topmast staysail.
Heave in stays—To come up into the wind while tacking ship.
"Heave or cast the lead"—Command given when depth of water in which vessel is sailing is desired to be known.
"Helm's a lee"—Helm is down. Answer of helmsman to order given in tacking ship.
Home—When sheets are close to yard, or when anchor is at hawse pipe.
Hove to—To lay aback main or fore yards in order to stop ship's progress; in heavy weather to keep ship's head (or bow) as close to the wind as possible.

IN IRONS—When ship will not obey helm in tacking.
In stays — Term used when the manœuvre of tacking ship is being performed, and vessel has lost headway.

JACKSTAY—Tight rope to which others are fastened; the iron rods secured to yards by eye bolts to which sails are attached.
Jacob's ladder—Rope sides and wooden treads.
Jettison—To sacrifice, by throwing overboard, part of a vessel's cargo in order to lighten her, with a view to saving the vessel from some imminent danger.
Junk—Old, condemned rope.
Jury mast, etc.—Temporary substitutes.

KEDGING—To move by means of small or kedge anchors.
Keelson—Timber or iron vertical plate on top of keel.
Keep away—Steer farther from wind.
"Keep her Full"—Command given when ship's sails are not filling properly.

Keep to the wind } Steer nearer to
Keep your luff } wind.
Kentledge — Pigs of iron or lead when used for permanent ballast.
Knot—A nautical mile.
LABOURING (of a vessel)—Rolling and pitching in a heavy sea.
Lanyard — A rope for tightening larger ropes.
Lash—To secure by ropes.
Lay to—To stop; to heave to.
Lazaret—A compartment above the after peak in a vessel for the stowage of provisions, etc.
Lead—Weight, usually made of lead, to ascertain depth of water. It is often "armed"—a cavity in bottom of lead filled with tallow, to find nature of bottom.
Lee—The side to which wind is blowing, opposite to weather.
Leech—Either side of square sail. The sides of triangular sails are named leech, luff, and foot.
Leech Lines—Small ropes attached to leeches of square sails and used in "clewing up" same.
Leeway—Drift to leeward; out of course indicated by compass.
Lifelines—Protection lines on yard, spars, or on deck to hold on by.
Lift—Rope near end of each yard to lift it or top it up.
List — Heeled over from upright position.
Load line — Water line along ship's side when fully laden. The statutory mark painted on outside plating or planking amidships of British vessels beyond which they may not be loaded; thus -⊖- (upper edge of bar passing through disc must not be submerged in salt water).
Luff—An order to steer nearer the wind; the fore part of a stay-sail, trysail, or jib.
Lying to—Keeping ship's head close to the wind, under storm sails, during stormy weather attended with a heavy sea.
MAKE SAIL—To set sail.
Marl—To secure things by a row of half hitches.
Marline spike—Steel spike used for splicing and rigging.
Martingale—A tackle and spur to prevent jib-boom from topping up.
Midships—The centre line or middle section of ship's deck.
Misstays—To try to tack and fail.
Moorings — Chains, hawsers, and warps used for securing a vessel to a quay or wharf.
NEAPED—To be in dock or on shore when neap tides do not provide enough water to float ship.
Near—Helmsman is too near the wind when steering by same.
Nip—Part of rope subjected to greatest strain.
"No higher"— Command given to helmsman when ship's course is directed too close to the wind.
Nun buoy—Double cone buoy.
OFFING—Distance from shore.
Off the wind—Not so close as she might be if sailing on a wind.
Orlop deck—Lowest in large ships.
O.S.—Ordinary seaman.
Overhaul—Slacken tackle; to examine; overtake.
PAINTER—Rope by which boats are made fast.
Palm—Implement made of stout leather, into which a steel indented disc is fitted, used by sailmakers to protect the palm of the hand when forcing a sail-needle through canvas.
Parbuckle—Hoist by rolling a thing in the bight of two ropes.
Parcel—To cover a rope with strips of canvas.
Parrel—Circular hinged band of iron round mast and secured to yard.

Pay a seam—To fill it with melted pitch.
Pay away or out—To slacken; to run out; generally applied to cables or warps.
Pay off—To sail off the wind; to pay and dismiss crew.
Peak—Outer part of gaff and of gaff sail; compartments at extreme ends of hold.
Pendant—Large rope with tackle attached.
Plain sail—All except studding sails.
Pooped—When wave comes over stern.
Preventer brace or stays—Additional supports to spars during a gale.
Purchase—A tackle or lever.
QUARTER—Part of sides near stern; middle halves of yards.
RAKE—Inclination of masts aft or forward from the perpendicular.
Ratlines—Ladders made of rope secured to the shrouds of masts; also the rope from which same are made.
Ready about, ready o' ready—Warning for tacking.
Reef points—Small ropes fixed to sails for reefing them by.
Reef tackles and pendants—Lines for hauling up leeches of sails before reefing.
Reeving line—Small line passed through block to drag larger one after it.
Rendering—Slipping, not holding.
Right the helm—Bring it amidships.
Rolling tackle—Ropes to relieve strain on yards in bad sea.
Round down—To overhaul.
Round to—Heave to.
Rudder — An appliance fastened to stern-post by means of gudeons and pintles, which controls the direction of vessels' movements when under way.
Running rigging—All ropes used in handling sails or yards.
SAG TO LEEWARD—Difference between ship's course as shown by compass and that actually made.
Sail close to wind—Sails of ship barely full.
Sail free—To keep sails clean full; off the wind.
Scarph — The connection of two pieces of timber or iron by shaping and overlapping their ends.
Scudding—Running before gale.
Scupper—Channel at side of decks, for water to run off by, through holes pierced in vessels' sides for that purpose.
Scuttle—Hole in side for light and air; to sink ship purposely.
Seizing—Small cordage, or flexible wire, by which two pieces of rope are firmly bound together.
Serving or service—Covering of rope with spun yarn or other protection.
Shackle—A U-shaped joining for chains.
Shears—Two large spars like an inverted V for lifting heavy weights.
Sheer—To swerve from course; the curve of the deck line between stem and stern.
Sheet—Rope holding lower lee corner of sail.
Sheet home—To haul sheets attached to clews of sails to position when setting same.
Shift helm—To put it over the other way.
Shorten sail—To take in some sails.
Slew—To turn or cant.
Splice—To join two ropes by intertwining strands.
Spunyarn—A thin line of two or three yarns of loosely twisted tarred hemp.
Square-rigged—Having yards on the masts.
Stand by—Be in readiness.
Standing part—Fixed ends of running gear.

Standing rigging—All fixed ropes and wires of ship's equipment.
Staysails—Small sails set on stays between masts.
Stevedore—Man who loads or discharges ships' cargoes.
Stiffness—Stability under sail pressure.
Studding sails—Small auxiliary square sails now rarely found.
Surge—To slack back quickly.
TACK—The lower weather corner of every sail; to change course by bringing wind ahead and round to other side; opposite to *wearing*, when wind is brought astern.
Taken aback—When wind suddenly shifts and all sails are thrown back.
Taut—Tight.
Thimble—An iron ring in a rope.
Throat—Upper corner of gaff sail near mast.
Throat halyards—For hoisting end of gaff next mast.
Thwart—Across. Cross seat in a boat.
Tiller—Lever to shift helm.
Top—Platform on crosstrees of lower masts. To top a yard is to lift up one yardarm higher than the other.
Traverse—To make several tacks.
Trestletrees—Wood or iron supports for crosstrees and standing rigging.
Trice—To haul up.
Trim a ship—To load her properly and ensure balance.
Trim sails—To brace yards and adjust sheets.
Trip anchor—To break it out of the ground.
Truck—Disc or ball at top of mast with sheaves for signal halyards.
Trusses—Fittings to keep centre of lower yards to mast.
Trysail—Triangular sail attached to lower masts, sometimes termed storm sail.
Tye—Large rope on which halyards act when hoisting a yard.
UNBEND—To untie and take off anything made fast, as casting adrift a sail from a yard or stay.
Under way — Moving under control of helm.
Underwriter — One who insures a vessel or her cargo.
Unmoor—To release a vessel from ropes or chains by which she has been held stationary.
VANGS—Ropes to steady gaff.
Veer—To slack out hawser or cable. Once was term for "wear."
Veer and haul—To pay out and haul in. The fluctuation in the direction of wind.
WAIST—Middle part of ship's fore-and-aft line on deck.
Wake—Track left in water; in way of.
Warp—Small hawser.
Warping — Transporting a vessel by means of warps or hauling lines.
Watches—Periods of four hours each, commencing at 4 a.m., with the exception of the dog watches, which are two hours.
Wear ship —see *tack*.
Weather gage—Bearing to windward of.
Weigh—To raise the anchor.
Whip—Single rope passing through block to increase purchase.
Whipping—Binding at end of rope to prevent fraying.
Windsail—Ventilator made of canvas.
"Work to windward"—Term used when a vessel is beating against adverse winds.
Worm—To fill grooves in a rope with twine or spunyarn.
YARD—Spar with spread sails.
Yaw—An accidental swerve from course.
Yoke — Small piece of hard wood fitted at right angles to the head of a boat's rudder, to which lines are attached for steering the boat.

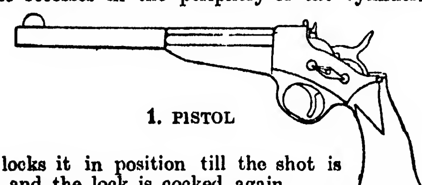
THE MANUFACTURE OF GUNS

Various Types of Pistols, Revolvers, Rifles. Sporting Guns and Machine Guns. Their Mechanism and Manufacture

By JOHN W. WAINWRIGHT

Pistols. The present type of pistol has a steel rifle barrel [1] fixed or with a drop-down joint, with fixed breech parts containing the striker and mechanism. The barrel is forged steel and rifled, the lock plates are of iron and steel, stamped and milled, and the action part springs. The butt is of walnut. The barrels are blued or browned. But the pistol has been almost superseded by the revolver and automatic pistol. Many revolvers and guns were made during the last two centuries having the cylinder revolved by hand, but the metallic centre-fire cartridge has enabled a great advance to be made.

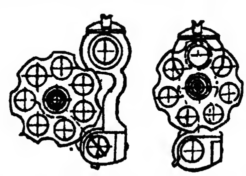
Modern Revolvers. The simplest modern type is the single-acting "Colt revolver" [2]. In this the cylinder, which contains six cartridge chambers, is made to rotate by the action of cocking the hammer. This causes pawls to engage in ratchet teeth cut in the rear face of the cylinder, and moves it one-sixth part of a revolution, and at the same time a small catch or latch engages in the recesses in the periphery of the cylinder.



1. PISTOL

and locks it in position till the shot is fired and the lock is cocked again.

In a later type the cylinder was swung out sideways to give self extraction [3]. This revolver had a solid bridge frame [FR in 2]. The frame or body is stamped hot—that is, forged by drop hammer between top and bottom dies. The fins of extended metal are dressed off by finning dies, and the stamping is then placed in a clamp jig or fixture for machining and the base pin hole is drilled through; the pin, previously prepared, is then inserted in order that each subsequent operation may conform with this centre. The frame still in the fixture is faced, the recess for the cylinder is machined out, and the barrel hole is drilled and tapped. The stock is shaped and spring beds recessed; all holes are then drilled and tapped, through the hardened bushes of the fixture. The frame is recessed for the hard steel shield which takes the thrust of the cartridge base.

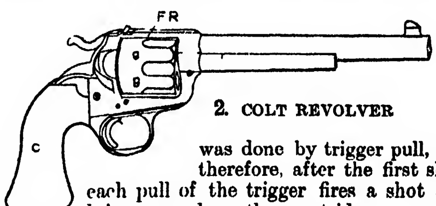


3. SWING-OUT CYLINDER OF COLT SERVICE REVOLVER

The Cylinder. This is either forged or of special rolled steel. The centre axis pin-hole is first drilled through and the cylinder is faced. The chambers are drilled and bored six at one time, in a multiple drilling machine; afterwards they are accurately chambered out to suit the cartridge. The front face of the cylinder is well fitted to prevent, as far as possible, the escape of gas. In the periphery of the cylinder the channels are now cut; also the slots for the latches are accurately milled out to an index plate to ensure true pitch, in relation to each other and the corresponding chambers; also, at the rear end, the ratchet teeth are cut. The limbs, or parts of the action, are of high grade steel stamped hot approximately to their finished form, and also machined in jigs or fixtures by automatic tools.

The Barrel. The barrel is bored, rifled and screwed; the outside is turned, the component parts are finished off by filing, and after hardening and tempering, they are sent forward in the bulk for section viewing—that is, for detail examination by gauges and to be assembled from promiscuous heaps, each part being thoroughly interchangeable. The sear and spring are then adjusted, to give a slight pull off, and the sighting corrected. Given these conditions, a champion revolver shot can fire as rapidly and accurately with a single-action revolver as with a double-action automatic [described later], the latter having a somewhat dragging pull.

Webley's Revolver. The next advance was a double-action revolver, Webley [4], in which the revolving of the cylinder and cocking the lock

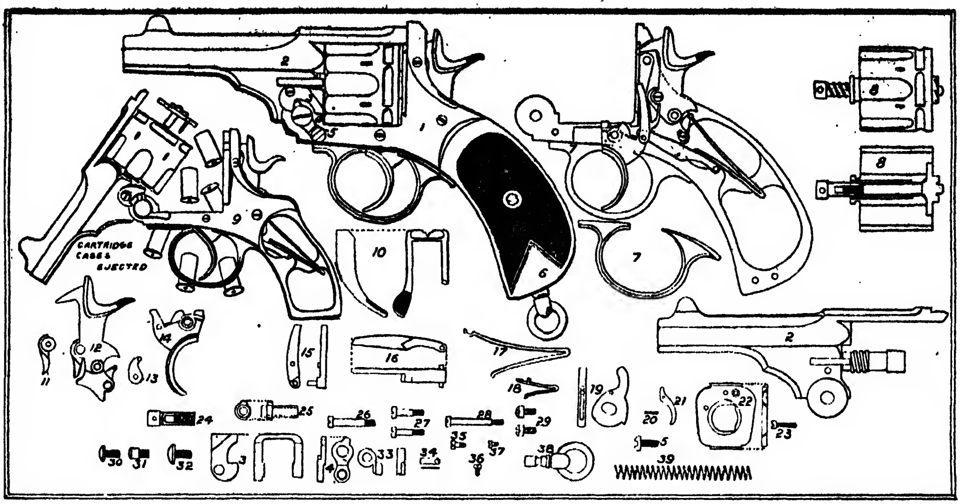


2. COLT REVOLVER

was done by trigger pull, and therefore, after the first shot, each pull of the trigger fires a shot and brings round another cartridge.

The frame is made of a solid steel stamping, forged under a drop-hammer in recessed dies, and milled out to receive the cylinder and drilled, all the work being done by the clamp jigs and fixtures to gauges with a maximum and minimum allowance, usually about ·002 in. to ·004 in., depending on the requirements. All the operations start from one face or point to ensure accuracy. The limbs are crucible steel stampings, machined all over in special jigs, by plain or finger mills or former mills. Each is tempered or case hardened where required, and inspected and tested, and the holes lapped out and the sears adjusted, the holes being tested by plug gauges through plates to see that they are at right angles to the part.

The cylinder must be truly concentric with the axis pin and the chambers co-axial with the barrel and in line with the striker, when the cartridge to be fired arrives at the upper position. This must also be assured by the latch engaging the corresponding recesses in the cylinder; moreover, the ratchet teeth on the back face must engage and disengage at the right moment, as must also the sears and bents, so that the motions synchronise. In others the barrel is swung down on a pivot below the axis joint pin, and the extractor is made to push out the cartridges. An extension of the



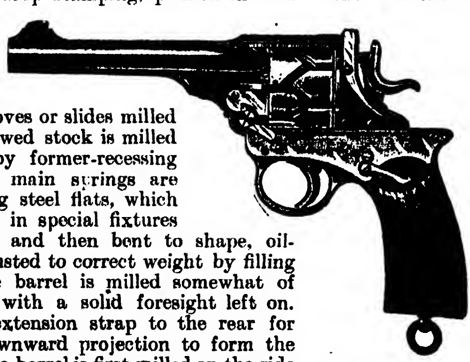
4. WEBLEY'S REVOLVER, MARK IV., DOUBLE ACTION

1. Body 2. Barrel and axis complete 3. Cylinder cam 4. Cam lever 5. Cam lever screw 6. Stock 7. Trigger guard 8. Cylinder and extractor complete 9. Cartridge cases ejected 10. Barrel catch 11. Hammer catch 12. Hammer complete 13 Hammer swivel 14. Trigger complete 15. Pawl 16. Main spring auxiliary 17. Main spring 18. Barrel catch spring 19. Extractor lever 20. Spiral spring, extractor lever 21. Extractor lever auxiliary 22. Shield 23. Screw, shield 24. Nut, extractor axis 25. Pin, joint axis 26. Screw, barrel catch 27. Screw, hammer and trigger 28. Screw, stock 29. Screw, guard 30. Screw, pin-joint axis 31. Screw, cam 32. Screw, cam lever 33. Trigger stop 34. Trigger stop spring 35. Screw, hammer catch 36. Screw, hammer stop spring 37. Screw, hammer swivel 38. Butt, swivel 39. Spring, spiral

barrel has a recess which is locked securely by a latch on the top of the frame. This locking gear must be well fitted.

Automatic Revolver. A further development is the automatic revolver—such as the Webley-Fosbery, shown in **5**. It consists of a frame and handle that does not recoil, and a recoiling part composed of the barrel body with mechanism and cylinder attached. The body recoils on explosion, sliding in a groove in the frame, and is returned by springs actuating a lever; at the same time a fixed stud works in the zig-zag grooves that are cut in the outer surface of the cylinder. The cylinder is rotated by the fixed stud for half the movement, then the stud passes down the return groove, thus completing the movement.

The frame is a drop stamping, pickled in acid to clean off the scale; the flat side surface is then milled or shaped straight across the top horizontal grooves or slides milled out, and the hollowed stock is milled or wibbled out by former-recessing finger-mills. The main springs are forged from spring steel flats, which are put in groups in special fixtures and milled across and then bent to shape, oil-tempered and adjusted to correct weight by filling or grinding. The barrel is milled somewhat of hexagonal shape, with a solid foresight left on. There is a solid extension strap to the rear for locking, and a downward projection to form the axis pin joint. The barrel is first milled on the side flats, and faced and drilled and bored. The axis pin joint is faced, and milled out by section mills, and the holes are drilled through. The hole for the cylinder axis tube is drilled and bored. The barrel and its extension is milled to section, and the latter radiused out to suit the cylinder, and the barrel is rifled and lapped out. The body stamping has a long rectangular portion to form the sides, an axis pin joint projection at the fore end, and a triangular block at the rear with its apex upwards. This last when machined contains the action. The bottom slides are faced and grooved out by section mills. The thrust face is squared across and recessed for the hard steel shield, and for the rear of the cylinder extractor and the various recesses milled out for the trigger and hammer, etc., to operate in, and the cross pin holes are then drilled through a jig. The hard steel shield, after being faced and machined outside and recessed, is hardened and ground true. The barrel catch is adjusted and fitted.



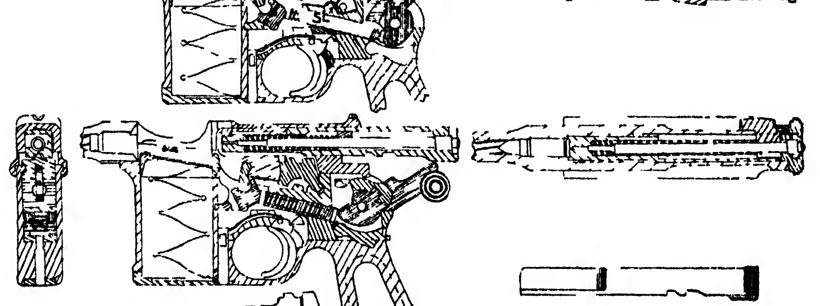
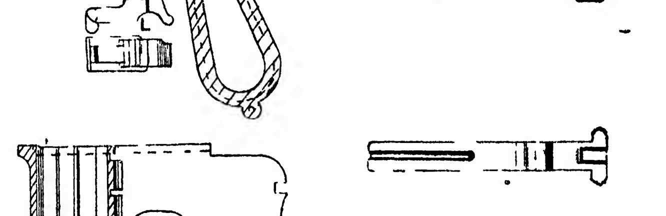
5. WEBLEY-FOSBERY AUTOMATIC SERVICE REVOLVER

The handle and the trigger-guard form the non-recoiling portion of the revolver. The handle has long slides grooved out by section mills in its top table for the body to slide on, and a recess cut out in front; also a fixed pin to rotate the cylinder. The stock projecting downwards is faced on both sides, and recessed out right through by former mills to contain the recoil-lever, which is fulcrumed at its lower end on a cross-pin. The stock also envelops the main spring and sear that hang downwards from the sliding body. The trigger-guard forging is shaped out and fitted into the handle together with the trigger. The stock is recessed by former mills for the two vulcanite side-plates. The rear plate of the stock is machined to form a hinge at its lower ends to give accessibility to the recoil-lever. The vulcanite plates are pressed to shape in hydraulic presses, and screwed into the recesses provided in the stock. The cylinder is manufactured as previously described, with the exception that in the place of the rear ratchet-teeth the exterior is grooved; this being done by placing the bored cylinder on a mandrel, which is revolved,

and special revolving finger mills form the grooves from a copy.

These grooves give the rotation to the cylinder when it recoils and returns with the body after each explosion. The action-limbs are machined in the same manner as described for revolvers. In assembling, it must be arranged that the slides and grooves work freely, but without jerk; the sears and bents are adjusted to engage and disengage correctly, so that as far as possible an even pull only is required on the trigger. The barrel and body, with the cylinder with the action attached complete, form a recoiling part, when the axis-pin is inserted.

When assembled complete and ready for firing, the revolver becomes automatic, in that the trigger on being pressed trips a sear and releases a hammer. After the explosion the barrel and body recoil, locking the hammer, and the cylinder is rotated by the fixed stud passing down one groove, and completing its revolution, by passing down the other groove by the reaction of the recoil-lever moving the body forward again, thus bringing a fresh cartridge into the firing position, and leaving the body and trigger and hammer, after again pressing the trigger, ready for firing. The parts are case-hardened and tempered where required.


6. MAUSER AUTOMATIC PISTOL

Mauser Automatic Pistol. This is illustrated in 6. The barrel is a solid steel stamped forging, with a round barrel and solid foresight, and a hollow, square extension forming the body, with two lower projecting lumps. The barrel is faced, and then drilled from end to end in a multiple drilling machine; it is then milled across to square the body, is slotted or milled across, and is then recessed through vertically between the breech and the body. The barrel is then draw-bored, and the interior of the body opened out to square section by shaper tools—like keyway slotters—and then to finished size by drawn drift-cutters. The barrel is finished, turned, and the foresight formed. The exterior is milled square, with projecting ribs left on the lower edges to slide in the frames. The bottom lumps [BL 1 and BL 2] are machined on the sides by gang-mills, and radiused for the bolt-lock L at the front end and also between the lumps, forming an oblong recess, which is carried up right through the bottom of the body. This latter recess is for the bolt-lock to pass through. A slot to take the stop-block is slotted through the side walls near the rear end of the body.

Bolt-lock. This has a tooth-shaped crossbar at the front end to fulcrum around the front of B L 1. Two webs extend to the rear end, joining a rectangular block with two locking teeth on its upper edge, and two legs projecting downwards. The rear legs rest on a supporting lug [S L] on the top of the lock-frame; and this leg, on recoil, slips down over the lug, the two legs straddling the lug and disengaging the locking teeth from the body. It is first milled on the outsides, and the recess wibbled out. The tooth is milled outside, and carefully inside, to form a fulcrum. The corners left by cutters are cleaned out so that it has a bearing right across.

Lock Frame. This is slid in from the rear into the main frame. It is of somewhat rectangular shape, with two webs projecting to the front to embrace the knife-edge fulcrum upon which the rocker works; also above this is a front-stop cross-member, which projects over the rear wall of the magazine. The main rectangular portion has a lug on the top face, and a bulb projection standing up at the rear, the latter to form a stop for the bolt-lock and a flat top over which the body slides. The rear of the block is recessed out to form the cheek-joints for the hammer to work between. The whole is secured in position by a rear stop-block pressing into a groove in the frame and recess into the main frame, and held down by a vee-spring.

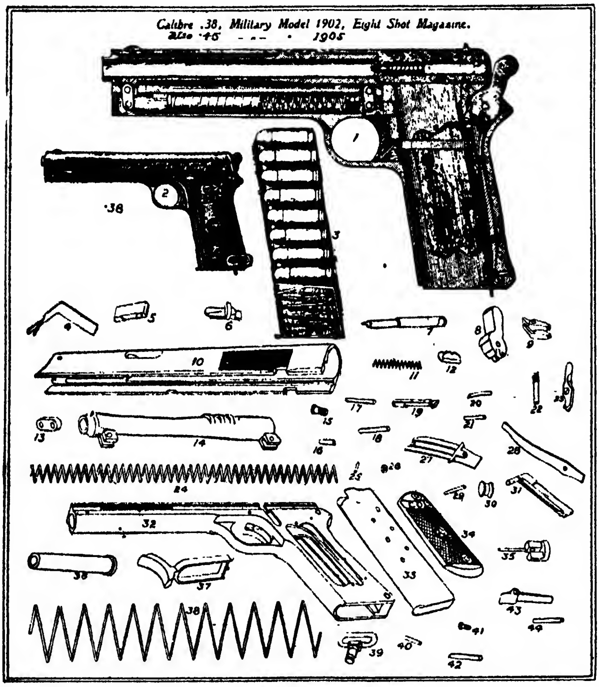
The stamping is first faced parallel on the sides, and on top and bottom. The cheeks are milled out, leaving a rear crossbar. The hammer axis pin-hole is drilled through a jig. Then the front face of the fulcrum-bar and the knife-edge of the same are shaped, and the hole for the mainspring is drilled out relatively to the axis-pin. The top lug, the recess for stop-block, and the recesses for lever and sear on one side are all machined to gauges, using the axis-pin and bottom and side faces as "spotting" points.

Main Frame. The main frame is a steel stamping. It has two projecting outside top slides and one inside, hollow, deep, oblong sides to contain the magazine in front, and also the lock-frame in rear, and it is continued down to form the

stock and trigger-guard. The stamping is first faced on the top table, then milled to section outside, to form the guides and faces, also the stock. The interior is drilled out with relief holes, and opened out by former mills. The stock is recessed right through, except where rebated for the vulcanite side-plates, and is machined out to form the trigger-guard.

Action. The hammer is a stamping. After facing, the axis pin-hole is drilled, and the faces and edges are milled to template. The front projection forms the sear-bent, and the lower projection is left to press against the mainspring plunger. The circular finger-grips are knurled. The action is then adjusted, hardened, and fitted.

The rocker is of hook shape, to engage the tooth projection of the bolt-lock. It has a round face,



7. COLT AUTOMATIC PISTOL

1. Longitudinal sectional elevation 2. Side elevation, assembled 3. Magazine loaded 4. Magazine follower 5. Slide lock 6. Slide stop 7. Firing pin 8. Hammer 9. Sear 10. Slide 11. Firing pin spring 12. Rear sight 13. Links 14. Barrel 15. Main-spring screw 16. Link pin, short 17. Firing pin lock pin 18. Sear and safety pin 19. Shell extractor 20. Shell extractor spring 21. Shell extractor pin 22. Hammer screw 23. Safety 24. Retractor spring 25. Hammer roll pin 26. Hammer roll 27. Sear, safety and trigger spring 28. Main spring 29. Ejector pin 30. Recoil plug 31. Ejector 32. Receiver 33. Magazine 34. Scales (2), right and left hand and escutcheons 35. Plug (take down) 36. Follower 37. Trigger 38. Magazine spring 39. Swivel 40. Swivel pin 41. Scale screws (4) 42. Plug and link pin, long 43. Magazine catch 44. Magazine catch pin

on which the mainspring plunger acts. An axis-pin is driven in to form gudgeons. It rests on the knife-edge of the fulcrum when the barrel is home, but is turned over and forced back against the mainspring on recoil, by the bolt-lock tooth. In manufacture it is made, in some cases, from a rolled section sawn across to length, and is then faced and the pin-hole drilled. It is hardened on the hook-point and fulcrum face.

The Bolt. The bolt is milled square in section outside, bored from end to end in a multiple-drill press to contain the striker and its spring. It has a long slot in the right-hand side, through which the buffer-stop to the spring is inserted. The fore end has a plug inserted with a taper-hole to contain the striker and its rebound spring. The rear end is also bushed, and the striker pinned in. The rear end has knurled horns for grasping when required to pull back by hand, to cock the lock at the start, or to fill the magazine. The notches are milled across the underside. In these the bolt-block teeth engage and disengage. A long V-shaped groove is milled on the underside for some distance from the front end. The top front has a recess and holes to bed in the extractor; the latter is a spring-tempered hook. The striker is of high grade, round-section steel, and is turned down in rod-feed hollow-spindle lathe, and the point tempered.

Another very good type is the Colt automatic pistol [7]. Its manufacture need not be described in detail. Complete sectional views are shown in the figure and a list of the component parts is gi en. It is adopted in the United States service.

Another automatic pistol of this type is Browning's Patent, which is used by the Belgian police and for householders' protection. Though small, it is very effective.

Military Rifles. Most of the modern military rifles have the door bolt type of breech and steel barrels, fitted with walnut stock, the cartridges being fed up from a magazine carried below the butt and front of the trigger guard. Typical of this class is the Lee-Enfield [8] and the Mauser [9], the former being used by Great Britain, and the latter by Germany, Belgium, Spain, Turkey, and other countries.

The chief difference in the breech-locking is that the lugs in the Mauser are at the front of the bolt and close up to the barrel, whereas in the Lee-Enfield they are at the rear, and this is considered bad practice by many experts, as the pressure tends to spring the bolt on an excessive pressure obtaining; moreover, as a long pillar practically unsupported, it is mechanically weaker.

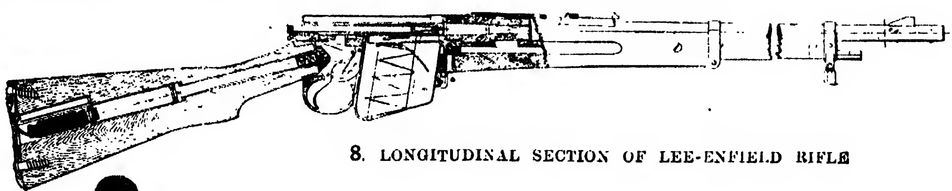
The Lee-Enfield Rifle. The number of component parts of the Lee Enfield is much in excess of the Mauser, but it has come out fairly satisfactorily through severe campaigns. The barrel is made from ·31 to ·41 carbon Siemens steel. It may be rolled, as at Enfield, from a round bar of suitable dimensions through a series of ten pairs of horizontal rolls, which elongate the barrel and taper it in transit, all in one heat. The work put on the barrel materially improves its capacity for standing the strain of the explosion. It is also claimed that this method enables the barrels better to retain their straightness during the drilling and following operation. But satisfactory barrels are also obtained by the use of the tilt or Bradley rapid blow-hammer, which is generally used on the Continent.

After this process the enlarged breech is stamped by steam or power hammers between top and bottom dies. The barrels are then cold straightened either in rolls, or in the machine shown in 10. They are then spun on centres, and finished, straightened by hand hammers very rapidly by experts, turned and clamp milled, that is, by

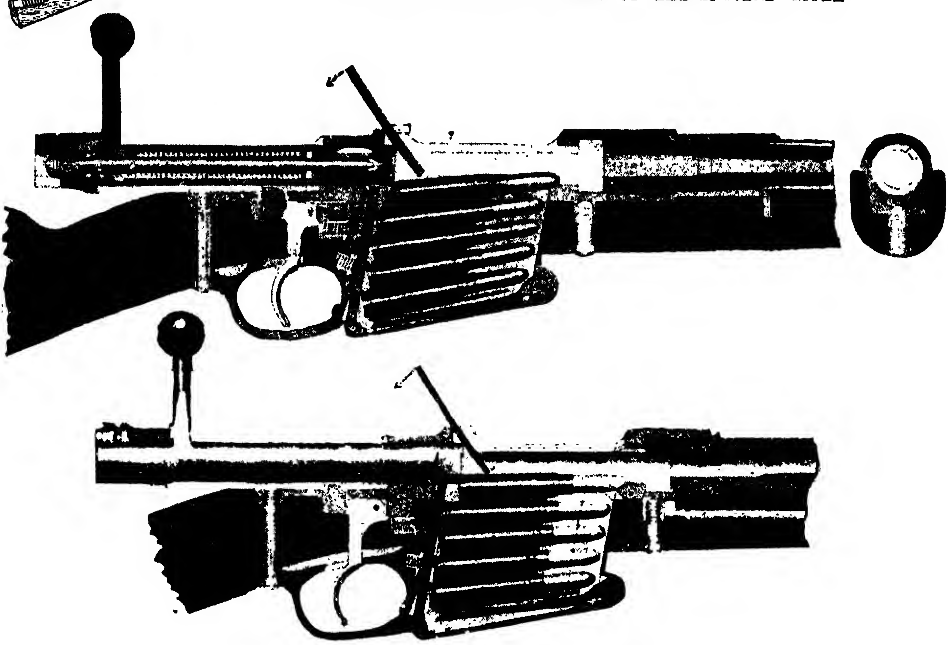
revolving cutters to gauge sizes in three places. These turned portions are called *spotting points*, the subsequent taper-turning work having reference to them, the ends are faced and centred, and afterwards drilled in a special drilling machine.

In the older practice, which is still followed, the barrel is drilled from both ends at the same time, the barrel being revolved at about 1,000 revolutions per minute, half round bits being used, at the same time a copious supply of soapy water being pumped at high pressure on to the cutting face through small brass tubes, carried along with the bits, thus washing the turnings out backwards, and also keeping the bits cool. The bits are made to vibrate to clear out the swarf more effectually. On arriving near the centre the operation is com-

They then place the tube or barrel across a hollow anvil, and give blows with a curiously shaped hammer. In the sighting and setting the men acquire marvellous dexterity, and are able to make the barrels absolutely straight in bore. The barrel is fine bored with a square bit, one or two corners of which are kept from touching the bore by wooden spills. Packings are inserted between the spills and the bar, to compensate for the wear of the cutting edge of the bit. The barrels are now second turned and polished, and are then ready for rifling, and again set. Furthermore, they are now tested in a machine for truth of bore, and any want of truth is indicated by the long arm of a lever of bell-crank shape; the short arm rests in the bore of barrel, which is spun on a tension mandrel.



8. LONGITUDINAL SECTION OF LEE-ENFIELD RIFLE



9. MAUSER RIFLE, SHOWING MAGAZINE

pleted by one set of drills. In later practice the barrel is drilled from end to end in one operation.

Draw boring follows this operation with a three-cornered bit of short length. the barrel revolving at low speed. It is again set as required. The barrel is then further turned, using the two spots at the ends and others in the centre, by several cutters or tools, the barrel being spring-supported by back rests; these latter, and the cutters, traversing the bed automatically, copy the taper or shape required from a fixed tangent bar.

After rough turning, the barrels are corrected by the barrel setters, who place the barrel at an angle with the muzzle towards a window with a horizontal board in its top pane, and looking through the bore observe any irregularity of the "shade" or shadow that is cast on the bottom of the bore.

Rifling. The usual method of rifling adopted in England is the old single hook cutter method. In the machine [11] the tool, when passing up the bore, is drawn in like a cat's claw, and then, being drawn out towards the muzzle, the hook tool cutter is pushed out. Each separate groove is thus cut or planed out to the required depth in the bore, while at the same time the required twist is given, in some cases by a fixed tangent bar, which causes a rack to traverse across the slide rest, and in doing so its teeth engage those of a pinion attached to the rifling bar, thus causing it to revolve, and in this manner to produce the required twist.

Other methods adopt a tail rod—that is, a continuation of the rifling bar, having grooves with a twist identical to that required to be produced in the barrel. Each groove engages a white metal

stud, which causes the tail rod to revolve, and thus directly imparts motion to the rifling bar. With its cutter box each groove is planed out separately, and its relative position to the next groove is guaranteed by advancing one notch of the division plate at the end. The rifling tool, or cutter box, is shown in detail [15], and will be described. Oil under high pressure is continuously pumped through a small tube on to the cutter; the shavings as they are drawn back, are examined by the rifler, and form a good criterion as to the state of the cutter and the inside work. Great care must be taken not to tear the grooves, but to get a clearly planed out cut from end to end.

Rifling Head Cutter Box. In this machine [15] the hooked cutter C at the end is solidly backed up by stop plunger P when cutting. The depth of the cut is regulated by screw adjustment, A, and an incline plane, I, up which the cutter is pressed by the spring S acting on its tail end. It will be seen that when making idle strokes up the bore the cutter is pushed down against the spring, but when returning on the cutting stroke it is pressed out again to the stop P. Other countries use drift cutters following each other through the bore with quick light feed, each drift following closely to the other. After rifling, the barrels are lapped out with lead laps in a lapping machine, and then pass to a polishing machine, which takes the grooves. Finally, a high revolving cylindrical lap finishes the *lands*—that is, the projections between the grooves. The thread of the breech end is then cut and rectified, and the barrel finished outside, cut to length, and the muzzle end rounded. The barrels are then sent to proof with a screwed plug on the breech end with a touch-hole through it, and returned duly stamped if correct. The barrel is then chambered to suit the cartridge. A good type of gauge has a taper plug used in conjunction with a cylinder, with a sector cut out.

10. BARREL-STRAIGHTENING MACHINE

The barrels are then browned. To do this they are first plugged at both ends, boiled in soda water, and covered with lime, then dried, and then immersed in a heated acid mixture and rusted, then scratch brushed. This treatment is repeated till an even surface is obtained. The barrel is then dipped into a bath of soft water with alkali to kill the acid, then cleaned off, and polished. The resulting surface is now practically rust-proof. The bolt and other components are also browned. After tapping for the sight-bed screws, and various inspections, the barrel is ready for sighting. The barrel is adjusted, and the sights fitted on and tested, then breeched up, and it must be correctly in line; also, when it is screwed up dead home the sights must be vertical.

Body. The body is made from a special mild steel, which is first broken down roughly to shape from the bar, and then stamped, and then the fins or extruded metal are cut off. The forging is then box-annealed in charcoal for half a day, after which it is pickled and placed in a dilute acid bath, which cleans off the scale. It is now ready for the various machining operations.

The body is first faced at both ends, then centred, and the breech face and the body drilled for the bolt hole in a multiple drilling machine; this hole is then drawn and fine bored. The hole in the socket end is drilled and tapped, in a jig or fixture. The recess for the breech screw is now opened out to the tapping diameter. It is then tapped in an automatic thread-milling machine. The work is held in a special chuck, and a milling bob is rapidly revolved, cutting into the bore to the full depth of the thread. The chuck portion with the work makes one revolution, but during this revolution it also has a longitudinal travel imparted to it by cams, equal to the pitch of the thread. By this means the whole of the thread is obtained. The machine has all its motions instantaneously arrested on the completion of the revolution by automatic gear. The face is then milled off accurately. The thread and face, together with the bolt hole, and with the tapped hole in the socket end and a flat face that is milled on for the tongue, form the spotting points or working faces, which enable the subsequent operations to be carried out relatively to them in the numerous jigs and fixtures.

The body in suitable fixtures is now passed to the various milling machines, the slides and various recesses accurately milled out to the correct contour and depth by former or profiling mills. Generally the latter consist of two overhung spindles on a vertical slide parallel and connected to each other, one having at its lower end a pin or stylus, and the other having cutters. With this arrangement and that of the freely-moving longitudinal transverse slides on the machine, any template or former fixed alongside the work will be copied, by the cutters or mills grooving out the solid metal as required. In addition to this some of the jigs allow the work to swing to cut out radial recesses or slides, and in others an end-on movement is given to form the helical recess for the locking lug. It is hardened at the recoil shoulders. The body stamping in its finished state weighs only about one-fourth that of the original, showing the large amount of machining done to this part alone. The action limbs are stamped out of high-grade steel and machined.

Bolt. This is of crucible steel and is stamped hot, and the handle set, finned, and then pickled to clean any scale off. It is then faced on both ends and turned where possible, and the knob milled. The ribs, etc., are milled, and it is then drilled through to contain the striker, then finished milled. After one hundred detail operations, the bolt is hardened and tempered and straightened.

Bolt Head. The bolt head is made of special gun-iron; it is a forging in most cases. After the facing and milling of the faces, the striker hole is gradually opened out and coned, the stem turned and screw milled, and the various recesses milled and slotted out. There are sixty operations. The head is then hardened, the screwed part being protected by fireclay.

Stocks. The stocks are of European walnut well seasoned, and without defects. The blocks are rough sawn to shape and turned in a copying lathe

by revolving cutters, as shown in **12**, and grooved out for the barrel and magazine, etc. In the case of the Mauser, it is in one piece, but the English rifle is divided into two parts, the butt and fore end.

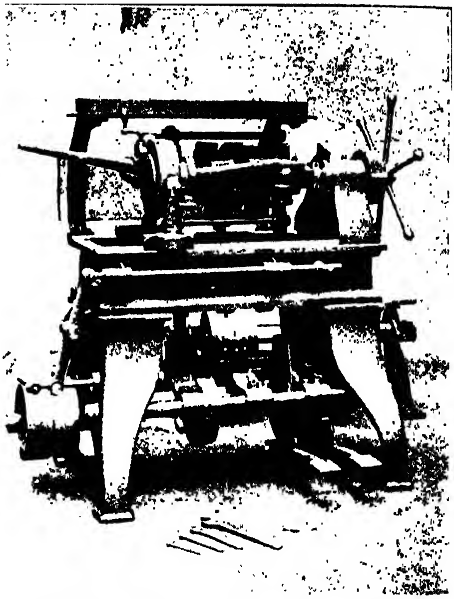
The barrel and body with bolt head and action are now placed in a carriage for final proof, and the compression of a copper crusher-gauge in rear of the cartridge head referred to, a known deflection of a similar copper cylinder, enables the maximum pressure on the base to be obtained. If correct, the parts are then proof stamped. The whole is now assembled on the stock, examined, adjusted and tested on the range.

The Mannlicher and Mauser bolt and action are much simpler, and can be stripped by hand in a few seconds. They are also much simpler for manufacture than the Enfield, and the bolt stands up to the work better.

The table below gives a list and full particulars of the magazine rifles used by various Governments. The tendency now is to make a lighter bullet, by decreasing the weight of the lead interior towards the nose, or by decreasing the calibre of the rifle, but should an absolutely reliable automatic rifle be produced, it would no doubt be adopted.

Sporting Guns. Sporting guns are made in great variety, and include single and double barrel shot guns, smooth bore, also rifled express guns. Nowadays, they are chiefly hammerless breech loaders.

The smooth-bore barrels are made from either (1) twisted and welded Damascus type, or (2) high-grade steel of special quality. The Damascus barrels, which have a beautiful pattern upon them, due to an arrangement of iron and steel twisted bars, which when acted upon by the acid, the steel remains light colour and the iron brownish.



12. LOEWE'S STOCK-TURNING MACHINE

This effect is produced by first piling the iron and steel alternatively with a larger proportion of steel for strength, then by rolling the same into rods, preferably of square section. In the English Damascus type three rods are taken; each is twisted on its own axis and then rolled together in a mill to the form of a ribbon. The ribbons are then coiled by gearing over a loose corebar. The coils are then brought to welding heat and welded around a mandrel by hammering. The thicker coils are then interlaced or scarped on the muzzle portion of the barrel, and the whole is drawn out to the required thickness and the protruding metal is cleaned off. It is to be noticed that the metal must be kept free from scale.

The resulting pattern in this type is that of a chain of interlocked circles, but

MAGAZINE RIFLES USED BY VARIOUS GOVERNMENTS

Country	Austria, Bulgaria, and Greece.	Great Britain		France	Germany	Japan	Russia
Pattern of the year	1895	1899	1903	1886	1898	1900	1894
Designation ..	Mannlicher	Lee-Enfield Mark 1*	Short Lee-Enfield	Lebel	Mauser	Year '30	"3 line" Nagant
No. of cartridges in magazine ..	5	10	10	8	5	5	5
Weight:							
Without bayonet	8 lb. 5½ oz.	9 lb. 4 oz.	8 lb. 2¼ oz.	9 lb. 3½ oz.	9 lb.	8 lb. 9¼ oz.	8 lb. 15¼ oz.
With "	8 lb. 15¾ oz.	10 lb. 3½ oz.	9 lb. 3 oz.	10 lb. 1½ oz.	9 lb. 14 oz.	9 lb. 8½ oz.	9 lb. 11¼ oz.
Length:							
Without bayonet	4 ft. 2 in.	4 ft. 1·5 in.	3 ft. 8·5 in.	4 ft. 3·12 in.	4 ft. 1·4 in.	4 ft. 2·5 in.	4 ft. 3·875 in.
With "	4 ft. 11·5 in.	5 ft. 1·5 in.	4 ft. 8·7 in.	5 ft. 11·84 in.	5 ft. 9·75 in.	5 ft. 5·5 in.	5 ft. 9 in.
Barrel:							
Length in.	30·12	30·19	25·19	31·496	29·05	$31\frac{1}{8}$	32·25
Calibre in.	·315	·303	·303 at breech ·305 at muzzle	·315	·311	·256	·3
Muzzle velocity	2,034	2,060	2,060	2,073	2,093	2,390	1,985

Mauser also used by Belgium, Spain, and Turkey.

Mannlicher also used by Roumania and Holland.

11. RIFLING MACHINE FOR B.C. GUNS

many other patterns may be obtained; one type is shown in **16** But this type of barrel is now being rapidly superseded by the weldless steel tube, which is more suitable for the modern nitro powder and the gun of the hammerless drop down type [**17**] with double extraction.

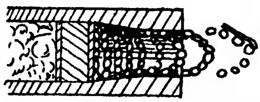
In shot guns the tubes may be drilled, drawn down or of drawn tubes, or forged out of the solid and drilled, as in express rifles. The usual methods of boring are somewhat similar to those described under rifle manufacture.

The latest practice is to drill through the bar of steel from end to end (instead of from each end and meeting at the centre) with a Loewe drilling machine, and finish the boring in one process, and any straightening is done mechanically or by hand setting. These tubes are then finished by the gunmaker and finished bored or choked to his special requirements.

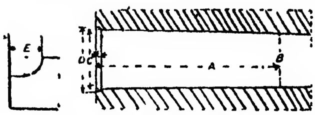
The outsides are not turned, but ground true by hand. Also, in addition to this, many barrels are choke bored. In one type, for instance, the muzzle is contracted to concentrate the shot, and this improves the target pattern. This is done by finishing the bore at the muzzle end with special tools of smaller diameter than the main bore, but some makers contract the muzzle by dies in the hydraulic press. The effect of this choking is shown in the diagram [**13**]. The bores are lead lapped out to get a fine polished surface. The tubes are subjected to a provisional proof to test the barrel, and afterwards to a definite proof.

One noted gunmaker uses the steel marked A for shot guns, and that marked B for rifles. Others use an excellent steel made by Messrs. Wm. Jessop & Sons, marked C in the table in next column.

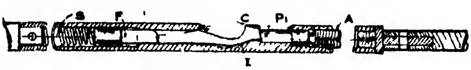
In double-barrel guns the tubes after proof are assembled and fitted together by the barrel filer with their ribs, lumps, etc. The top and bottom



13. DIAGRAM OF EFFECT OF CHOKE BORING ON SHOT



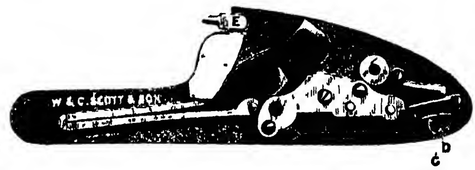
14. MINIMUM CHAMBER DIMENSIONS



15. RIFLING MACHINE CUTTER BOX HEAD

16. PATTERN OF DAMASCUS BARREL

17. SPORTING GUN Hammerless Drop Down Type



18. SIDE LOCK PLATES WITH MECHANISM

TABLE OF GUN TUBE STEEL

	Tensile tons per sq in.		Elongation.	Contraction.
	Ultimate.	Elastic limit.	Per cent.	Per cent.
Shot guns (A) ..	35·	25	25	48
Rifles (B) ..	52·	28	20	41
Messrs. Jessop's steel (C) ..	58	41½	23	49 (rolled bar)
	48	32	30	65 (same annealed)

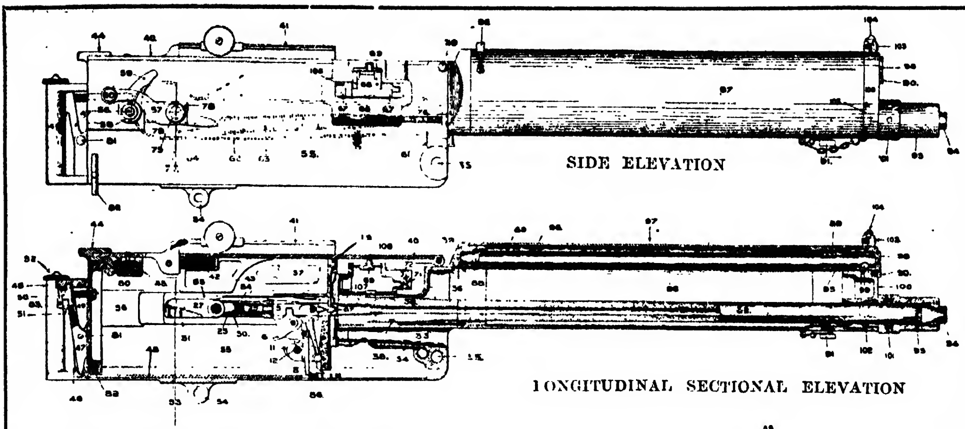
ribs are fitted and jointed up, the inner edges of the barrels being filed so that they converge. The top ribs may be fluted or shaped as desired. The breech lumps and wedge pieces are brazed on. The breech body, already machined, is now fitted on. The jointing up of the breech is an important item in drop-down guns, and these parts are filed and scraped to fit together in the most careful manner. The holes and ends must also be dead square, so that all parts transmit the shock to the fixed breech, but at the same time the gun must open freely and with regularity. The locking bites must be tight with no slogger. The extractors, which have usually two legs, are fitted in to work freely, and the end faces when home must not project beyond the breech end of the barrel.

The breech body is usually made from a solid forging with front or fore-end projection, a flat squarish part for the mechanism (action). This block is machine recessed for the mechanism, but in many cases two side lock plates are fitted to carry the lock mechanism, as shown in **18**.

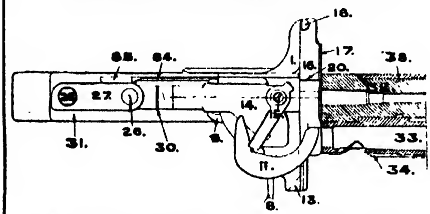
There are a great variety of extractors; many of these are actuated by the fore end, which eases the cartridge case and flips it out completely when clear of the standing breech. At the same time the mechanism cocks the hammer. In all cases the

APPROVED MINIMUM DIMENSIONS FOR GUN CHAMBERS

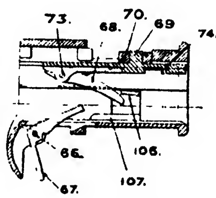
BORE	5 ·976	8 ·835	10 ·775	10 ·775	12 ·729	12 ·729	12 ·729	14 ·693	16 ·662	20 ·615	24 ·579	28 ·550	32 ·526	·410	360
A	4·000	3·250	3·250	2·875	3·000	2·750	2·500	2·500	2·500	2·500	2·500	2·500	2·500	2·000	1·750
B	1·060	·914	·841	·841	·798	·798	·798	·760	·732	·685	·650	·614	·560	·462	·420
C	1·080	·930	·857	·855	·813	·812	·811	·773	·745	·698	·663	·627	·573	·472	·429
D	1·177	1·015	·934	·934	·886	·886	·886	·844	·813	·761	·722	·682	·623	·522	·479
E	·088	·076	·070	·070	·067	·067	·067	·063	·061	·057	·054	·051	·050	·050	·050
F	·049	·043	·039	·040	·037	·037	·038	·036	·034	·032	·030	·028	·025	·025	·025



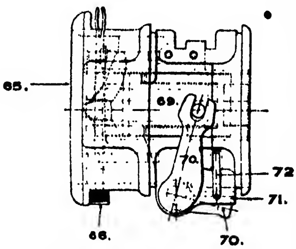
19. MAXIM AUTOMATIC R.C. GUN



20. LOCK OF AUTOMATIC R.C. GUN



21. FEED BLOCK OF AUTOMATIC R.C. GUN (SECTION)



22. FEED BLOCK OF AUTOMATIC R.C. GUN (PLAN)

striker must be clear of the barrel face before the gun is opened out.

The body fore end and action and lock plates are hardened in animal charcoal, or the steel action components are hardened and tempered by gas-muffle furnace with oil and water hardening.

The walnut stocks are sometimes shaped (as described in rifle manufacture), but in sporting guns most of the stocks are varied in length, set, and shape to suit the balance of the gun and the purchaser. They are highly finished and polished; also the gun may be finally decorated by engraved lines. A list of the approved minimum dimensions for various gun chambers is shown in the table at the bottom of preceding page, which refers to the dimensions of **14**. The taper in all cases is ·005″ per inch in length.

Maxim Automatic Machine Gun. It is necessary to explain that this gun is fully automatic—that is to say, after firing the first shot the explosion causes the barrel and lock to recoil together and the following cycle obtains. The empty case is withdrawn from the barrel at the same time that a loaded one is pulled out from the belt. The barrel returns home again, causing another loaded cartridge to be brought forward in the belt, into the feed box, by moving the belt. But the lock continues its rearward course, cocking the lock; and, coming forward again, raises up and inserts the loaded cartridge into the barrel, seizes another full one in the belt, having ejected the empty case; and, lastly, when the breech is quite securely home, the trigger is tripped, releasing the firing pin, and again firing the gun. The recoiling parts of the gun are brought back by a strong fusee spring situated at the left-hand side of the gun. That the reader may follow out the action of the gun, and so become acquainted with the various parts, we reproduce drawings [**19** to **23**] furnished by Messrs. Vickers, Sons, & Maxim. Each part is numbered on the drawings, and the names of the parts to which the numbers relate are as follow.

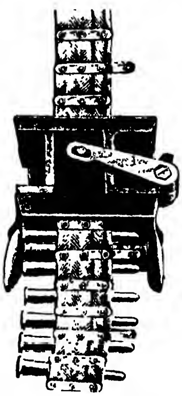
1. Lock casing 2. Safety sear 3. Sear spring 4. Sear axis pin 5. Firing pin 6. Tumbler 7. Tumbler axis pin 8. Trigger 9. Trigger axis pin 10. Lock spring 11. Extractor levers 12. Axis of extractor levers 13. Lower extractor stop. 14. Side levers 15. Side lever axis pin 16. Extractor 17. Cartridge grooves 18. Horns of extractor 19. Upper extractor stop 20. Notch for extractor holding up spring 21. Gib 22. Gib spring 23. Gib cover 24. Extractor spring 25. Connecting rod 26. Crank pin 27. Crank 28. Crank shaft 29. Connecting rod nut 30. Washer for connecting rod 31. Recoil plate 32 Barrel 33. Ejector tube 34. Ejector tube spring 35. Crosshead joint pin hole 36. Trunnion block 37. Inside cam 38. Cannelure for asbestos packing 39. Cover joint pin 40. Cover 41. Tangent sight 42. Tangent sight spring 43. Cover block 44. Cover lock 45. Cover lock spring 46. Rear crosspiece 47. Firing lever 48. Trigger bar 49. Firing lever spring 50. Double button on firing lever 51. Automatic safety catch spring 52. Milled head with oil brush 53. Bottom plates 54. Hole for elevating joint pin 55. Outside plates breech casing 56. Filling-in piece 57. Crank, roller 58. Roller 59. Check lever 60. Knob on crank handle 61. Crosshead lug 62. Fusee spring box 63. Fusee spring 64. Fusee links 65. Feed block 66. Bottom pawl axis pin 67. Bottom pawls 68. Top pawls 69. Feed block slide 70. Feed block lever 71. Bracket retaining feed block lever 72. Spring retaining feed block lever bracket 73. Top pawl axis 74. Top pawl spring 75. Hexagon of crank shaft 76. Fusee spring adjusting screw 77. Fusee 78. Crank bearing 79. Slot in outside plates in which crank bearings move 80. Stop screw for firing lever 81. Firing lever axis pin 82. Rear crosspiece fixing pin 83. Automatic safety catch 84. Guides in which flanges in lock move 85. Crank stop 86. Projection on trigger bar 87. Extractor firing pin hole 88. Steam tube socket (rear) 89. Holes in steam tube 90. Screw fixing steam tube 91. Emptying plug 92. Filling plug 93. Muzzle attachment 94. Muzzle attachment plug 95. Steam tube 96. Slide valve 97. Water jacket 98. Steam tube socket (front) 99. Steam escape hole 100. End cap 101. Gas escape holes in muzzle attachment 102. Muzzle asbestos packing 103. Foresight fixing screw 104. Foresight 105. Cork plug 106. Feed block spring guide for cartridge cannelure 107. Cartridge stop

It is to be noted that when firing automatically a complete cycle occurs in the space of $\frac{1}{16}$th of one second.

Barrel. This is of very high grade "Vickers" steel drawn down under a Ryder hammer from a round bar. While at the muzzle end it is about the same thickness as a rifle barrel, it is much larger at the breech end. At this end it has a reduced part reinforced by a block with barrel trunnions on each

end. This is screwed on to the barrel, and has in it a stud on each side called the *trunnion bearing* to attach it to the recoil plates, and is recessed for a cartridge head and extractor. The barrel is bored and finished, rifled and chambered in a similar manner to the ordinary rifle barrel; but it is also hardened internally for some distance from the breech to withstand the high temperature of continuous firing. This is done by heating this portion of the barrel, after it is rifled, in a muffle, and then by attaching an oil and water injection pipe, through which first oil is forced and then water. This gives it a harder surface well in front of the shot that prevents the lands and grooves of the rifling being washed away or eroded by the flame of the nitro-cellulose powder. It is then finished, chambered, and touched up, bobbed out to correct any little irregularities due to the hardening process, and finished turned, and also has a deposited copper coating on its outer surface; the breech block is then screwed on dead home in such a way that the axes of the trunnions are at right angles to the axis of the barrel.

Casing. This consists of two plates with two hardened cam plates riveted on, a bottom plate, a rear crosspiece, and a hinged top cover. The side plates are of saw plate quality, and are first flattened out, and then edge planed, drilled to template, and two hardened cam plates are riveted on inside. These control the path of the carrier. In each side plate is a gap extending to the rear edge, for the crank bearing of the recoil plates to slide in. The rear portion is milled to a V shape, and filling-in pieces are fitted in, to close this portion. They can be removed when the rear block is taken off, so that the barrel and all the action can be withdrawn. The bottom plate is of bronze. It is drilled, and the side plates are riveted to its angle fillets. There are also gaps machined through for the feed box, and pin holes for the spring box on the left-hand plate.



23. FEED BOX AND BELT, MAXIM R.C. GUN

Cover. The steel cover has a gunmetal casting with cam projections downward on it to ensure the extractor dropping on recoil of the lock. They also keep the lock down when back. This casting (which also contains a recess for the backsight spring) is machined first and riveted in the correct position; a spring catch is fitted on the rear end of the cover. Holes are drilled for the tangent sight in the upper face, and a milled-out hinge piece is riveted on the front end. The rear crosspiece is a gunmetal casting with a bottom hinge to the side plates; also a pin to secure these passes through them. This pin has a turned T-head split pin to make it readily removable. The rear crosspiece is milled out to take the firing lever, and drilled for its pivot pin. A gunmetal safety catch with its springs is attached. The gunmetal castings on arrival from the foundry are well cleaned and pickled in acid solution and then machined in fixtures to templates and gauges.

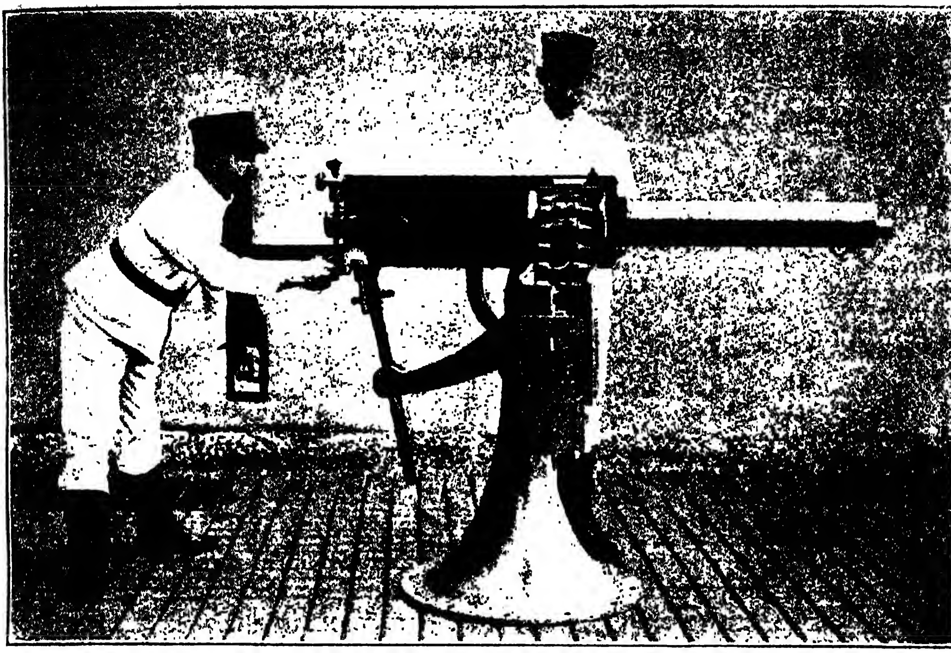
The Water Jacket. The water jacket is made up of a rear block and tube and front cap. The tube is either a bronze casting, or, as in the latest type of steel, with corrugated gills.

The rear block for the water jacket is a bronze casting joining by screw threads to the water jacket in front, and extending rearwards to form a sleeve for the barrel with an ejector tube below it; its top portion has hinged cheeks for the lid. At the side are two dovetails to form a rigid connection with the casing. This casting requires very careful coring and moulding to prevent contraction flaws. After casting it is pickled and sent to the machine shop. The sides are planed or milled parallel, and the fore end turned and screwed. The front and rear faces are milled to length, and the male screw thread is cut on its fore end. The holes for the asbestos-packed barrel breech are bored out and carefully finished to give a good sliding fit to the barrel. The top face is milled across, the hinge cheeks milled through, and the pin holes drilled. The dovetails must be very carefully machined and fitted on to the casing, being driven home with a raw hide or lead hammer. It is drilled for the axis pin and recessed for the extractor spring.

The Tube. When this is of bronze it is a cylinder cored hollow; it must not be porous. It is turned up and polished outside, screwed at both ends, and the sight bed is machined. A water plug and drain plug are screwed in. When in position it must be adjusted so that the sight is vertical.

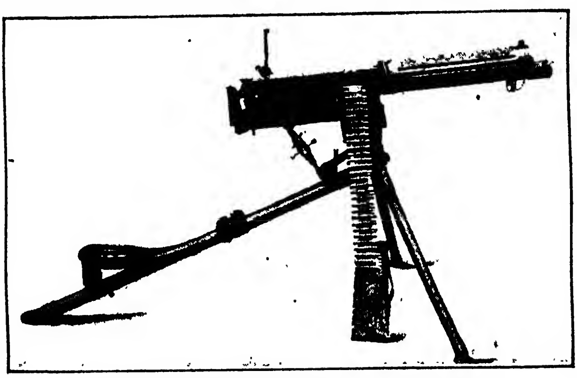
Front Cap. This is a bronze casting with front gland, with asbestos packing to make hydraulic slide joint. There are screwed plugs to receive the steam tube end. When assembled, a boring bar is passed through this gland and the bearing in the rear block to ensure correct alignment, or this would grip the barrel and prevent it sliding properly.

Lock Frame. This [20] is of steel, broken down from the bar, and is a beautiful stamping with the vertical horn web and slides, also side trunnion projections raised up. It is first faced on the front face and slides and wibbled out on the sides, and the two solid side trunnions are formed by hollow mills through a fixing. Then the interior is milled out between the side cheeks in a jig, using the two first machined surfaces as spotting points; then a guide race for the firing pin is slotted out longitudinally, the striker hole is coned out, and the top stop machined. After the outside of the side walls are machined, the pin holes are drilled and reamered out through a jig, so that they are true to pitch and square with the rest of the lock frame when the lock frame is completed outside. The side levers are previously machined, are slipped over the side bearings, and joined together at the rear by riveting them on a square block. The block has a projection rearward forming the male portion of the bayonet joint, and the extractor lever stampings are machined and mounted. The various components, firing pin, and tumbler are machined and hardened. The front face of the thrust block, on which the base of the cartridge rests, is tempered very hard. In front of the lock frames, and gripping it with flanges, is the extractor. The extractor contains a gib with its spring and back plate, and the tail spring. The centre portion is a solid block, through which the point of the striker passes. The front face also has small flanges vertically, but these are discontinued below to liberate the empty cartridge case when in the up position. This component is carefully recessed out by former mills for the gib; also the cone for the firing pin is bored out, and the grooves to form the guides milled. The tail spring is riveted at its lower end to the extractor.



24. 37-mm. MAXIM AUTOMATIC SHELL GUN (POM-POM)

Recoil Plates. These are flat steel plate stampings with square crank bearings stamped up; the left-hand plate has a forward prolongation with an open slot, which engages the bell crank lever, and gives transverse motion to the cross slide of the feed box. It is squared first on the top and bottom edges, and then the outside faces are milled across, leaving the crank bearings projecting up. The insides have projections inwards left on them to form stops to the upward movement of the crank cheeks; also grooved guides are milled in them to contain the extractor slides on the front end. The crank axis holes are drilled and bored out dead square with the plates in jigs, and the front fork or slot of the left-hand plate is machined out with a slight radius The slides and fore end and axis holes are all oil hardened, after heating in a muffle furnace.



25. LIGHT AUTOMATIC GUN ON TRIPOD

Crank and Connecting Rod. The crank is a solid stamping with two web cheeks and axles projecting on each side of them, hexagonal at one end for the hand lever, and at the other for the fusee. They are first turned on the axle parts. The cranks are milled out between the webs, leaving a wedge-shaped portion there; also, outside, they are machined by gang mills. The crank pin hole is bored through the cheeks in a jig and slightly countersunk, and then the finished pin is riveted in place.

Feed Block. The feed blocks [21 and 22] are bronze castings, and contain the steel pawls, slide, and lever. The casting is machined longitudinally outside to fit the casing plates, and transversely inside to suit the various shaped cartridges, also for the cross slides, and bored for the lever. The bottom steel pawl has a fixed fulcrum in the casting; the top pawl is on the slide. The longitudinal movement of the recoil plates imparts a transverse movement to the slide through the bell crank lever, and the top pawl slides back over the cartridge and feeds it forward on the return stroke, the bottom pawl retaining the cartridge belt [23] in position.

Hotchkiss Machine Gun. The only other type of automatic machine gun that has been adopted is the Hotchkiss, which is used by the French and other Governments. It is simple and effective. It has no water jacket, but a very thick radiator barrel, and the number of working parts is small. It can be stripped and reassembled by hand if necessary without the use of tools. It was in use in the Boer War. Another type of Maxim gun, or Pom-pom, is shown by the 37-mm. shell gun [24] somewhat on the same principle as the R.C. type described. This gun fires small shell of about $1\frac{1}{2}$ in. diameter. The latest type of light R.C. Maxim gun is shown in **25.**

Continued

FURS AND FURRIERS

The Quality and Colour of Furs. The Various Processes Involved in their Preparation. Making the Skins into Articles

By J. P. MILLINGTON

THE covering of certain animals is known generally as fur. In speaking of a "fur," the term is usually applied to the pelt or skin proper, and the wool or hair attached to it. On examination of most furs, two kinds of fibres will be noticed—those making up the under-wool, which are soft and flowing, and stiffer, straighter ones, more closely resembling those of human hair. The latter are of service in keeping the woolly fibres from becoming matted or felted, and also assist in keeping the wool from being saturated with water, as they allow the water to shoot away "as from a duck's back."

The value of a fur-skin depends upon the colour, texture, and durability of these fibres, and also upon the nature of the pelt; and it is because they possess one or all of these characters to a high degree that certain skins are held in such high estimation.

Colour and Quality. The colour of wild animals is generally well adapted to the surroundings amongst which they severally live and have their being. Generally speaking, the farther north we go the lighter do we find the prevailing colours, and it is only in the extreme north that white animals are found in any appreciable quantity. Cold has a marked influence on colour, and many animals whose summer coat is grey or even drab assume during the winter a more or less pure white colouring, though, as a rule, certain portions retain their original share of pigment, as, for example, the Arctic hare, which has some pigment remaining in the tips of the ears, and the ermine, in which the tail is yellowish white at the root and black at the tip.

Like colour, quality is influenced by climatic conditions. As a rule, the colder the winter the better is the fur, and those skins taken about mid-winter are usually better both in quality and colour. When the new coat begins to appear, certain of the half-grown fibres are to be seen. A skin in this condition is said to be "stagey," and is generally much poorer in quality. Summer skins are those obtained from animals wearing their summer clothing. These also are of considerably lower quality than those taken in winter.

The Application of Furs. In the first place it should be pointed out that the skins of fur-bearing animals are used for two main purposes. Their chief application is to the manufacture of articles for domestic use—wearing apparel, rugs, etc. In the second place, the fur, after being separated from the pelt, is converted by pressure into felt used in the making of hats, cloth, and so on. In addition to these uses, there are certain other industries on a smaller scale which deal in fur products, as, for example, the manufacture of badger-hair brushes, and of artists' brushes from sable and kolinski tails. Our chief concern will be with the fur trade proper in connection with the collecting, trading, preparing of furs, and their manufacture into saleable articles of clothing.

Before proceeding to an account of the treatment of furs, it will be as well to give a short account of the fur-bearing animals. For details concerning their nature, habits, and relationships, see the course on NATURAL HISTORY. We shall consider them here only so far as they are important from the furrier's point of view.

FUR-BEARING ANIMALS

Angora. [See GOAT.]

Badger (*Meles taxus*). Found across temperate parts from Britain to Japan. Rather stiff greyish upper hair, and whitish under-wool. The hair is used for making brushes.

Bear (*Ursus*). Various species are used by the furrier. The brown bear (*Ursus arctos*) is found all over the Old World north of the Atlas and Himalaya ranges. Fur varies much in colour and quality, that of the cubs being woolly while that of more adult members of the species is stiffer.

The *Grizzly Bear* (*Ursus ferox*) is found distributed over a large area in North America. The under-wool is brown or dark brown, and the hair almost black. Certain skins yield hair suitable for brushmaking, but the majority is used for ordinary furrier's work, and large numbers are employed in the manufacture of caps and robes for military purposes.

The *Polar Bear* (*Ursus maritimus*) is found only in Arctic regions. The fur of the young is quite white, but becomes yellower with age, though some adult specimens are of an almost pure white. A certain number of skins are used for rugs.

Beaver (*Castor*). Two species only are known—the European beaver (*Castor fiber*) and the American beaver (*Castor canadensis*). The former is widely distributed over Europe and Asia; the latter is practically confined to Canada. The fur is a very beautiful one of a grey-brown or reddish colour, with rather long, somewhat stiff hairs. Usually, beaver skins are "pulled"—that is to say, the upper hair is removed and the colour of the fur altered by a chemical process known as "silvering." Beaver is used largely for trimmings, coat linings, and sundry other purposes, the old application to the making of hats being practically a dead industry. The numbers annually taken have of recent years shown a marked decrease, owing to persistent hunting.

Blue-backs. [See HAIR SEAL.]

Buffalo (*Bos americanus*). Found in western and northern American prairies. Hair rather coarse and dun in colour. Used chiefly for making leather, though the finest skins are made into robes.

Cat (*Felis*). Various species used in fur work. The domestic cat, of which large numbers are obtained from the Continent (more particularly from Holland), is used in large quantity for fur work of an inferior kind. The skins are made into linings for coats, etc., and these are known as "genet." Fur poor in quality; colours various.

Wild Cat (*Felis catus*). Poor in quality and in limited demand.

Civet Cat (*Viverra zibetha*). Sometimes used on account of singular markings.

Chinchilla (*Chinchilla lanigera*). Found in various parts of South America—the finest qualities in Peru. The hair is very soft and of almost the same length as the fur. The fur is long and silky, in the ground parts of a dark slate colour, while the upper portions are silvery grey. Used very largely for muffs, boas, and trimmings.

Another variety, known as *Bastard Chinchilla*, comes from Chili. The skins are smaller and the fur poorer than the real chinchilla.

Caragan. A variety of fox found on the steppes.

Deer (*Cervus*). Many species are found in various parts of the world. There is little fur, and the hair is rather short and stiff. Chiefly used for making mats, rugs, etc.

Ermine (*Mustela erminea*). Found in Russia, Siberia, and North America. Hair and fur both soft. The best almost pure white. Inferior qualities have a more yellowish tinge, and are frequently bleached before use. Tail yellowish, with a black tip. Used for muffs, boas, trimmings, etc.

Fisher (*Mustela pennanti*). Found in northern parts of America. Fur rich and close, hair long, dark and glossy. Pelt strong, and the whole skin of a durable nature.

Fitch (*Mustela eversmanni*; also *M. putorius*—the pole-cat). Found in various parts of the Continent and in Siberia. Hair long, with dark tips. Fur light grey to yellow. Used very largely for cheaper varieties of fur work.

Fox (*Canis*). Many species and varieties used for all kinds of fur work [8].

Black Fox (*Canis vulpes argentatus*). Found in North America and in Russia. Best from Labrador district. Fur fine, and dark in colour. Hair long and glossy. Value varies according to colour, the darkest being the most valuable.

Blue Fox (*Canis lagopus*). Found in Arctic regions. Best from Archangel district and others from Greenland. Fur soft and woolly, of a blue colour, hair of a grey-blue colour.

Continental Fox. European red fox.

Cross Fox (*Canis vulpes pennsylvanicus*). Found in North America—best come from the Hudson's Bay district. Fur pale in colour; hair darker at the tips, the darkest parts being along the spine and across the shoulders, making a distinct cross [c d].

Grey Fox (*Canis cinereo-argentatus*). Found in America. Fur greyish or yellowish; hair silver-grey on the back, more yellow on the sides.

Japan Fox (*Canis procyonoides*). Poorer in quality than above. Hair greyish and somewhat stiff and short [8b].

Kitt Fox (*Canis velox*). Found in some parts of Russia and in North-West America. Skins small; fur and hair rather soft.

. and Fox. Name usually given to red fox from Germany and Switzerland. Smaller and poorer than Asiatic and American kinds.

Red Fox (*Canis vulpes*). Found all over the northern hemisphere. Some of the best come from America, of which there are two varieties—western and eastern—the former being the finer. Very fine skins are also obtained from North Europe—those from Finland are, perhaps, the best. Very fine skins come from Asia, the Kamchatkan kind being particularly good. Colour of fur various, yellowish to blue-grey. Hair yellow to a rich dark red [8c and e].

Silver Fox (*Lanis vulpes argentatus*). A variety of the black fox obtained in Russia and North America. Fur dark in colour, hair silvery white.

White Fox (*Canis lagopus*). Found in North America and in North Asia. Fur and hair pure white, though the former often has a tinge of blue. Sometimes darker hairs are present. These lower the value of the skin. Enormous numbers are dyed various shades [8a].

Genet. [See CAT.]

Goat (*Capra hircus*). Found in many parts of the world. The Angora possesses fine silky fur, and is largely employed in the making of rugs. Certain kinds of goat obtained from Thibet and China come into the London market in enormous quantities, and are classified according to colour into "whites," "greys," and "natural blacks." The best skins of the last-named class are dyed to imitate bear, and are much used in the manufacture of rugs. Some of the finest come from China and Manchuria.

Guanaco (*Lama acus*). Found in South America from Ecuador to Tierra del Fuego. Colour reddish to yellow. Chiefly employed for making carriage rugs, etc.

Hamster (*Cricetus frumentarius*). Found in large numbers in Germany and on the Continent. Fur and hair short, yellow to grey, with curiously shaped black markings down the back. Made into linings for coats, cloaks, etc.

Hare (*Lepus europæus*). Found in northern hemisphere. Fur soft and fine, hair long and fine, pelt weak. Pure white found in Russia and Siberia in enormous numbers. Thousands used in this country in the natural state, and dyed to imitate the more costly varieties of furs. Sold by the *poud* (a Russian measure). Value according to the weight in *pouds* of 100 skins.

Kaluga (*Spermophilus citileus*). Found in Central Europe and Siberia. Practically no fur, but very short hair. Poor skins in every way, both as regards fur and pelt. Colour grey, yellow, or reddish. Made into coat linings, etc., and often dyed some darker colour.

Kangaroo. Various species used to a slight extent.

Kolinski (*Mustela sibirica*). Found in Northern Asia. Fur soft and short, of a blue-grey colour in the ground, lighter on the top; hair yellow to orange-red; skins generally dyed to look like sable, and used for muffs, stoles, etc. The hairs from kolinski tails are used in making artists' brushes and pencils.

Lamb (*Ovis aries*). Many varieties are known in the fur trade, and have received names according to the districts from which they are obtained—*e.g.*, Persian, Krimmer, Ukraine, Astrachan, etc. The fur is curly, the value depending on the size and tightness of the curl. The better the curl, the more valuable the skin.

Persian lamb is the most valuable, as, when dyed, it takes a most beautiful gloss. Ukraine, Astrachan, etc., are less valuable, but are largely used. Colours are various. A certain number of pure white skins are used in the natural state ... turely. Lamb from Western Europe has a longer wool, and is used for lining gloves, etc.

Leopard (*Felis pardus*). Used for rugs, etc.

Lion (*Felis leo*). Used for rugs, etc.

Lynx (*Felis lynx*). Obtained in Europe. An American species (*F. rufa*) is also used in fur work. Fur grey, yellowish or bluish. Hair fine and soft, of a greyish colour, flecked with black. Many used natural for ties, etc., some dyed, chiefly blue and black colours.

Marmot (*Arctomys*). Various species obtained in Europe and Asia are employed. Different kinds are known by special names—*e.g.*, Orenberg marmot, Tarrabagan, etc.—and the values differ according to the kind. Fur is rather harsh, generally of a greyish black colour in the ground, becoming lighter and more yellowish red at the top. The hair is reddish, often speckled with black, and rather stiff and harsh. The skins are generally dyed to imitate the more costly sable.

Marten. Various species belonging to the genus *Mustela* are used. The whole genus is characterised by a certain softness and richness of the fur, which makes them amongst the most highly esteemed furs.

American Marten (*Mustela americana*). Found principally in the Hudson's Bay district, Labrador, Alaska, and certain other parts of North America. The fur is bluish grey, except under the throat, where it is a yellowish white. The top of the fur is lighter in colour, and the hair varies from a light yellow to a rich dark brown. Next to the Russian sable, it is the most valuable skin of the marten tribe. The darker the skin the more valuable it becomes.

Baum Marten (*Mustela martes*). Found in Central and Northern Europe and in Asia. Fur rather like that of American marten, but somewhat lighter. The hair is fine and soft, and varies in colour from light yellow to dark brown. The fur on the throat is of a yellow to deep orange colour.

Fisher Marten. [See FISHER.]

Japanese Marten. This is a much less valuable fur than the preceding, both on account of its harsher nature and of its brilliant colouring value, which ranges from yellow to orange.

Japanese Sable. In character this skin rather resembles that of the Chinese sable, which seems to be a variety of the Russian sable.

Russian Sable (*Mustela zibellina*). One of the most highly-prized furs. The fur of the best skins is of a rich, greyish blue in the ground, becoming somewhat lighter towards the top. In character it is exceedingly soft and "full." The hair is dark brown and glossy, and here and there greyish hairs are to be seen. The lighter-coloured skins are much less valuable and are frequently dyed to look more like the darker natural skins.

Stone Marten (*Mustela foina*). Found distributed over Southern Europe, some of the finest skins being obtained from Turkey, and in certain parts of Asia. The fur is of a lighter colour than that of the other martens, and is generally of a pale greyish blue colour, though in many skins it is almost white. The hair is very long and less soft than in the other species. In the best skins it is of a dark brown colour.

Mink (*Mustela*). Various species are used.

European Mink (*Mustela lutreola*). Found in Poland, Russia, and Eastern Europe generally. It is known as "nörtz" or "sumpf-otter," and is not used in large quantities.

American Mink (*Mustela vison*). Occurs in America. The fur and hair are short, and vary from a pale yellow to a rich brown. The upper lip is generally white, and there are also white patches on the breast.

Japanese Mink (*Mustela sibirica*). Closely allied to the Siberian mink, and resembles the polecat tribe. Its fur is short, rather harsh, and of a yellowish colour.

Mole (*Talpa Europœa*). Found distributed all over Europe. Very fine, soft fur, short and close, of a bluish-grey colour. Has been used in exceedingly large numbers during recent years for jackets, etc.

Mongolian. Under this name are included the skins of various animals from Thibet and China. The skins of certain kids from these districts are sewn together in the form of a Maltese cross, and are known as China kid crosses. The small pieces of fur which cover the legs are also made up in a similar fashion, and are sold under the name of "kidleg crosses." They are generally classified according to colours, four principal varieties being recognised—viz., grey, white, black, and mixed, or spotted. The value depends on the quality and length of the fur, the longer and coarser varieties being the least valuable. The name "Mongolian" is often used as synonymous with Thibet lamb, a species of sheep having long, soft, curly wool.

Monkey. Certain species from West Africa, with fur of a bluish-grey colour, have a limited use.

Moufflon (*Hircus laniger*). Found in various districts in Europe and Asia. The hair is "pulled," leaving a soft wool. Skins are dyed various colours—blue, grey, etc., and are used for making necklets, etc. The true moufflon (*Ovis musimon*) is found only in Corsica and Sardinia. The skins of certain Mongolian goats are also known as moufflon.

Musquash (*Fiber zibethicus*). Found in North America. The hair is coarse and generally dark, the fur soft, close,

and of a rich, grey-blue to slate colour. When "pulled," the fur shorn so as to be of about 14 millimetres in length, and dyed, these skins are used very largely for making ladies' jackets, as the finished article is a very passable imitation of sealskin. One variety, known as "natural black musquash," which is obtained from Maryland and Delaware, is of much greater value than the ordinary kind.

Nutria (*Myopotamus coypu*). Found in the River Plate, South America. The hair is coarse and stiff, and is usually removed by "pulling." The fur is short and close, and of a rich brown colour. For use as trimmings for ladies' garments it is often "silvered." [See BEAVER.] The fur of skins of which the pelt is damaged is much used for felt manufacture.

Opossum. Two varieties are used by the furrier—the American and the Australian. The characters of the furs of these two animals are quite different. In the American opossum (*Didelphys virginiana*) the hair is long and coarse, often split at the ends. The fur is generally white or ashy grey. In the Australian opossum (*Phalangista vulpina*) the hair is shorter, less stiff, and the whole effect is more woolly than in the American form. The colour is usually blue-grey on the back, while the belly fur is white or yellowish.

Otter (*Lutra*). The otter is found distributed over a large portion of the earth. The European species is *Lutra vulgaris*, and some of the best skins come from Norway, though occasionally good ones are obtained in the Shetland Islands. The Canadian otter (*Lutra canadensis*) is also largely used. A very large otter is obtained in South America (*Lutra braziliensis*), and a certain number of these skins are used by the furrier. The African species (*Lutra capensis*) is large in size, but the quality of the fur is rather poor.

Sea Otter. [See SEA OTTER.]

Platypus (*Ornithorhyncus paradoxus*). Found in Australia and Tasmania. The fur is not of first-rate quality, and has but a very limited use.

Rabbit (*Lepus cuniculus*). Found all over Europe, and its fur is perhaps one of the most largely used. Many thousands of tame rabbit skins are used on the Continent. When shorn and dyed they are used as an imitation of sealskin under the name of "electric seal." Several varieties are known to furriers and fur merchants, and amongst them may be mentioned Blue Rabbit. The last-named is used as imitation ermine, and for millinery purposes. The fur is also largely employed in the manufacture of felt for hats, etc. The American rabbit has fur more resembling that of a hare.

Raccoon (*Procyon lotor*). Found in North America. Fur long and well developed, greyish or yellowish grey in colour; hair often flecked. Pelt strong and durable. Largely used for linings and rugs. The tail is ringed with black.

Sea Otter (*Latax lutris*). One of the most valuable furs at present in use. Found in the North Pacific. Formerly it was comparatively common, but persistent hunting has greatly reduced the numbers. The fur is very full, rich, and soft, and its colour varies from a greyish brown to an exceedingly dark brown. The pelt is extraordinarily strong and thick.

Seal. Under this name are included many species which may be conveniently divided into two main groups—the fur seals and the hair seals. In the former class the fur is very thick and soft, while in the latter it is reduced to a minimum.

The Fur Seals. There are four species used in the fur trade which are classified according to the districts from which they are taken.

Alaska Fur Seal (*Otaria ursina*). Found in the Behring Seas, and the greatest numbers are taken on the seal beaches of the Pribylov Islands, and those belonging to the Aleutian group. The hair is stiff and strong, the colour varying according to age. The fur or wool is very thick, and after removal of the hair is seen to be of a greyish yellow or brown colour, and tightly curled. (This description applies in the main to the other three varieties of fur seal.) The seals taken in the open sea and known to commerce as "North-West Coast seals," as well as those taken off the coasts of the Copper Islands, also belong to this species.

Cape Horn Seal (*Otaria australis*). Found in the South Pacific. "Lobos" skins, caught near the Lobos Islands, belong to this species. The fur, as a rule, is not so thick as in the Alaska seal.

Cape of Good Hope Seal (*Otaria pusilla*). Found in the neighbourhood of the Cape of Good Hope. Somewhat similar in general characters to the Cape Horn seal.

New Zealand Seal (*Otaria forsteri*). Found near New Zealand and in the South Sea Islands. The fur in favourable specimen of "South Sea skins" is very long and full.

The quality of the fur depends to a great extent upon the age of the animal. Three or four year old seals generally possess the richest and thickest fur. According to the size they are sorted and named as follows, beginning with the largest: Wigs, middlings, middlings and smalls, large pups, middling pups, small pups, extra small pups, grey pups, and black pups. Further details concerning fur seals is given later.

The Hair Seals [9]. Various species from the Pacific are known to commerce—*e.g.*, the Cape sea lion (*Otaria jubata*), the Northern sea lion (*Otaria stelleri*), the Californian hair seal (*Otaria Gillespii*), and the Australian seal (*Otaria lobata*). Those most frequently met with are the Atlantic varieties, of which the following are the most commonly used.

Grey Seal (*Halichœrus grypus*). Found in North Atlantic. Certain numbers breed in the Shetland Islands. Not very plentiful.

Common Seal (*Phoca vitulina*). Found all round the British coasts. The hair is yellowish with black spots on the back and flanks, yellowish white on the belly [9c].

Ringed Seal (*Phoca hispida*). Found in the North Atlantic. The hair is stiff and of a yellowish colour, marked down the back and flanks in the form of rings of blue or black hair.

Blue-back (*Phoca grœnlandica*). Found in the Northern seas. The hair of the back is a bluish grey—sometimes quite a dark blue, while on the flanks and belly it is white or yellowish white [9b].

Whitecoat. The young of various species of hair seals having their first coat are known as whitecoats. The fur is soft, the hair softer than in the adult, and varying in colour from silvery white to light yellow. Some are even of a pale orange colour. The hair seals are used chiefly for the making of coats for motoring, though whitecoats, when dyed, are used for making military caps, etc [9a].

Sheep (*Ovis*). Three kinds of wild sheep are used in the fur trade—viz., the argali (*Ovis argali*), from Siberia; the moufflon (*Ovis musimon*), from Sardinia; and the American sheep (*Ovis montana*). There is generally a stiff hair and a soft under-wool. The former is usually removed by the process known as "pulling."

The lambs are very largely used under names denoting their place of origin—*e.g.*, Astrachan, Persian, Ukraine, etc. Caracule, from the south of Russia, is largely employed.

Skunk (*Mephitis mephitica*). Found in North and Central America. Of a dark brown, almost black colour, with dark under-wool. Generally, there is a more or less well-defined white stripe of a V-shape. Dark skunk are valuable skins, both on account of their colour and durability. The white stripes are often cut out, sewn together, and then dyed to imitate the darker portions. Largely used for muffs, ties, collars, etc.

Squirrel (*Sciurus vulgaris*). Found in the northern parts of Europe, Asia, and America. The common red squirrel is not much employed, the kind chiefly valued being the Russian and Siberian. The fur is soft, full, and of a rich dark slate colour, and the hair is grey, slightly flecked with a darker blue. The belly is white, while the flanks are often slightly red. Squirrel is largely used for coat linings. The skins are divided into back and belly, and the backs made into what are known as sacs. These, when dyed of a sable colour, form a very tolerable sable imitation. The bellies are also sewn together to make "squirrel lock sacs." The best varieties of Russian squirrel are known as Obsky, Tobolsky, and Lensky.

Susliki. [See KALUGA.]

Thibet Lamb. [See MONGOLIAN.]

Tiger (*Felis tigris*). Found in Asia. Chiefly used for making rugs, etc.

Vicunia (*Lama vicunia*). Has practically the same distribution and characteristics—as regards fur—as the Guanaco, and the skins are employed for similar purposes.

Wallaby (*Petrogale xanthopus*). Found in Australia. Fur soft; hair rather long, and of a greyish colour. Largely used when dyed as an imitation of skunk.

Whitecoat. [See SEAL.]

Wolf (*Canis lupus*). Found in the northern parts of Europe, Asia, and America. Hair fine, wool soft, and very liable to "felt." Best come from Siberia and the Hudson's Bay district. Colour varies from yellowish grey to blue, some skins having hair that is almost black.

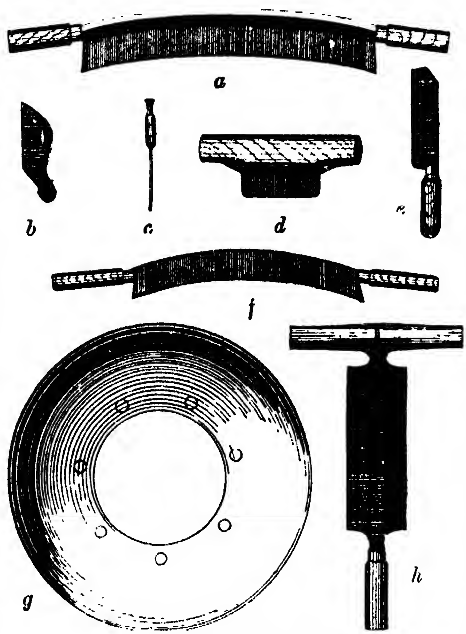
Wolverine (*Gulo borealis*). Found in Arctic regions. Known also as the Glutton. Fur soft and thick. Colour somewhat similar to that of the wolf.

The Trade in Furs. At the present day there are certain recognised centres of the fur trade, and to these almost all the skins are brought and sold either by private treaty or by public auction. Amongst these centres are London, Leipzig, Nijni-Novgorod, and Irbit. To the London market come all the goods belonging to the Hudson's Bay Company. These are sold by public auction twice a year, in January and March, the chief skins being beaver, musquash, red fox, white fox, cross fox, kitt fox, silver fox, mink, otter, American

marten (known as Hudson's Bay sable), fisher, lynx, wolverine and wolf.

Furs collected in America other than those of the Hudson's Bay Company are sent direct to London—and a small number to Leipzig—where they are received by commission agents and subsequently sold. To London also come most of the South American (chinchilla, guanaco, nutria, etc.) and Australian furs (opossum, wallaby, kangaroo, etc.), as well as large numbers of what are known as "China goods," including goats, Thibet lambs, China kid, and kid crosses, Jap fox, Chinese sable, weasel, kolinksi.

The fur sales in London take place in January, March, June, October, and December. At the December sales practically the whole of the world's seal catch is disposed of to merchants, who distribute them between London and Paris for dressing, dyeing, and those subsequent operations which are necessary before they are ready to be made into jackets and other articles. At the March sales, which are the largest, almost every conceivable variety of skin is to be seen, and at this time of year certain parts of the City seem to be more than usually cosmopolitan, for merchants come from the ends of the earth to prepare for the following winter. The China goods are sold mostly in January, and, as in every other branch of trade to-day, there is a tendency to specialisation to be seen, for certain business houses devote almost the whole of their attention to this China trade. About Easter time, Leipzig presents a similar cosmopolitan aspect, for then the great fur fair is held. At this fair the majority of the goods sold are those obtained from the Continent of Europe—including part of the Russian produce, and, in addition to the various kinds of sable and marten, such as stone and baum marten, fitch, kolinski, etc., large numbers of American skins—skunk, beaver, musquash, etc.—are sold.



1. THE FURRIER'S TOOLS
a. Beaming knife b. Furrier's knife c. Shaver's ste d. Sleeker e. Unhairer's pulling knife f. Blubberin knife g. Moon knife h. Cross-handled shaver's knife

To Irbit, one of the centres of the Russian trade in furs, are brought Russian furs, such as marmot, hare, and fitch, white fox, ermine and squirrel, as well as lambs of many kinds—Persian, Ukraine, Krimmer, Astrachan, and others. The skins are sorted, half-prepared, and sold, to come eventually to Western Europe, often *via* Leipzig and London.

The fair at Nijni-Novgorod was formerly the greatest in the world. Here, East and West met to haggle and barter, buy and sell. To-day, however, it is of considerably less importance, though still the centre for Siberian goods such as ermine, hare, sable, squirrel, and other furs.

At the London sales all goods are sold by public auction to the highest bidder. Goods must be cleared from the warehouses by a certain fixed date, so that many merchants and furriers who do not wish to have their goods worked immediately have them warehoused. Some skins are best kept in cold stores; for others it is sufficient to put them away at the ordinary temperature with some substance which will prevent them from being attacked by moth. Camphor is excellent for this purpose, but on account of its lower price naphthalene is much more largely used.

Tariffs and Duty on Furs. The Customs duty on furs was abolished in 1845 after having been reduced three years earlier, so that all skins, whether raw, dressed, or dyed, come into this country free of charge. The same applies to Germany, but in France, dressed and dyed skins are charged duty according to tariff, with the exception of certain China goods, and some kinds of hair seals.

All raw goods are admitted duty free into the United States, but charges are made upon dressed skins amounting to about 20 per cent. of the value, while for manufactured articles an even higher rate is charged.

There are also certain tariff charges in Canada and some of the Australian Colonies.

So much then for the trade in raw products on the large scale. The courses usually adopted in retailing are two in number. The merchant, having obtained his goods, sorts them according to colour and quality, and either sells them in the raw state to the furrier, or to another merchant, or hands them over to the fur-skin dresser and dyer. By the latter they are dressed—that is to say, the hard, horny skin is converted into a soft, pliable pelt of the nature of chamois leather, and, if necessary, shaved down to a suitable thickness. Certain goods require dyeing in order to improve their lustre and colour generally, or so to change them in appearance that they resemble a more costly and pleasing fur. From the dresser and dyer they pass once more into the hands of the merchant; from him to the furrier, and so to the retailer of the finished articles. Certain furriers, however, prefer to buy the raw goods from the merchant, and have them prepared according as they are needed, this applying particularly to the more valuable varieties.

Prices of Skins. In the following list, the prices and numbers given are only to be read as approximate. It is impossible to obtain accurate figures as regards numbers on account of the enormous amount of business that is done by private treaty at the various Continental fairs, and, in addition to this private sale there is still, at Leipzig, at any rate, a certain amount of barter. Russian merchants, for example, exchange Persian lamb for the red fox of their German brethren. Amongst the skins which are sold by auction to only a small extent are squirrel, marmot, fitch, nutria, baum and stone marten, kolinski, and Persian lamb,

and of these any figures that may be given represent but a small fraction of the total number.

With regard to prices, we are again forced to approximate figures. As a rule, two prices are given, the one representing the lowest grades and the other the highest. Between the two are innumerable values.

There are various causes which determine the prices, the principal being demand, which is ruled by the dictates of fashion, and supply, which is practically beyond control. A few seasons ago, there was a large demand for moleskins, and whilst the fashion lasted millions of skins were made up into jackets, muffs, and other articles of wearing apparel. At the present time the demand is considerably lessened, and, in consequence, far fewer skins come to the market. Persistent hunting frequently causes a shortage in numbers, and disease and increase in the number of the natural enemies of fur-bearing animals are also contributing factors.

2. FLESHER AT WORK

APPROXIMATE PRICES AND NUMBERS OF FURS ON THE MARKET

Kind of fur.	Number.	Value per skin.
Badger [etc.	17,214	1s. to £1
Bear, Brown, Black,	15,744	5s. ,, £10
,, Polar	153	£1 ,, £25
Beaver	48,975	10s. ,. £2 10s.
Chinchilla (real)	8,935	4s. ,, £7 10s.
,, (bastard)	36,083	1s. ,, £1 5s.
Cat, Civet	79,065	1s. ,, 2s. 6d.
,, House	58,122	2d. ,, 2s. 6d.
,, Wild	16,070	1s. ,, 7s. 6d.
Ermine	13,022	1s. ,, 10s.
Fisher	4,909	5s. ,, £3
Fitch	—	6d. ,, 5s.
Fox, Blue	3,589	£1 ,, £9
,, Cross	5,438	5s. ,, £5
,, Grey	55,638	1s. 6d. ,, 5s. 6d.
,, Japan	83,420	3s. ,, 8s.
,, Kitt	5,252	1s. 6d. ,, 5s. 6d.
,, Red	74,773	2s. 6d. ,, £1 15s.
,, Silver	1,546	£2 ,, £220
,, White	29,054	7s. 6d. ,, £2
Goat	—	1s. ,, 7s. 6d.
Kolinski	—	1s. ,, 4s. 6d.
Lamb, Astrachan	—	1s. ,, 3s.
,, Krimmer	—	3s. ,, 5s.
,, Persian	—	12s. ,, £1
,, Ukraine	—	3s. 6d. ,, 6s. 6d.
Lynx	58,919	6s. ,, £2 2s.
Marmot	—	2d. ,, 3s. 6d.
Marten, American	98,129	15s. ,, £15
,, Baum	—	12s. ,, £3
,, Japan	14,575	2s. 6d. ,, 12s.
,, Stone	—	5s. ,, £1
Mink	241,000	2s. 6d. ,, £2
Moufflon	—	4s. ., 7s. 6d.
Musquash	5,335,820	5d. ,, 3s.
Nutria	—	—
Opossum, American	422,494	6d. ,, 3s.
,, Australian	1,028,640	6d. ,, 8s. 6d.
Otter	16,637	6s. ,, £10
Raccoon	366,142	1s. ,, £16
Russian Sable	19,423	1s. ,, £25
Sea Otter	340	£2 ,, £200
Seal, Fur	—	£1 ,, £10
,, Hair	7,535	1s. ,, 10s.
Skunk	908,633	1s. ,, 14s. 6d
Squirrel	—	6d. ,, 1s. 6d.
Thibet	350,000	2s. 6d. ,, 7s. 6d.
Wallaby	—	1s. ,, 5s.
Wolf	48,112	1s. ,, £2 10s.
Wolverine	1,063	1s. ,, £2 10s.

There are few who would recognise as things of value the rather unpleasant skin of the fur seal as it comes to the fur-dresser, covered with salt on the fur side, and its natural coat of thick blubber on the pelt side, or the shapeless-looking object with a hard, horny skin which later forms part of my lady's sable set. Yet it is to this recognition of value and quality in the raw state that most capable fur merchants owe their success; and it is due to the skill and energy of the dresser that the pelt is made into leather as soft as chamois, and the fur and hair cleaned and laid as Nature intended, so that the unsightly and often evil-smelling raw skin becomes a thing of beauty and a joy to its owner. Frequently, furs which are inferior in natural colour are dyed to resemble the more pleasing skins, and of this process more is said later.

Curing the Skins. The first process, the curing of the skins, is usually performed by those engaged in the work of capturing fur-bearing animals. It consists essentially in removing the skin with its attached fur from the body, removing excess of fat, and drying in the air. Certain skins, however, such as fur seals, bluebacks, calves, etc., are dressed with salt before packing. Mention is made of this later when considering the dressing of seals.

As stated, in the case of most animals the skin is stripped from the body and dried. This removal of the skin is usually effected in one of the three following ways: (1) An incision is made in the middle line of the ventral surface from mouth to rump, and the skin carefully cut away. This method is almost universally employed in the case of marmot, chinchilla, and Australian furs, such as wallaby and opposum. Large skins—e.g., bear, goat, sheep, etc., are also treated in this manner. (2) The animal is opened at the mouth and rump and the body of the animal drawn through. This is by far the most usual practice, and most of the smaller skins with which the fur dresser has to deal are thus obtained. (3) The body is drawn through the mouth, leaving the rump or "breech" end closed. Usually the legs and tail are opened and the bones removed, though so cleverly is this method employed by certain hunters that although the breech is not opened the tail and leg bones are taken out, in all probability with some sharp rod-like instrument. Many Russian sable and stone marten come to the dresser in this fashion.

One animal—the nutria, from the River Plate—is remarkable in that the belly fur is better than that of the back, and in consequence the removal of the skin is always effected by making a longitudinal incision down the centre of the back instead of the belly. As a rule, the head, legs, and tail are left attached, though this is by no means a universal custom. In seals, the fore flippers are cut off, and in the skin as received from the curing house are to be seen two round or elliptical holes marking the places which the flippers occupied [5]. Many skins, such as goat, Thibet, marmot, wallaby, nutria, come to the market minus heads and tails and legs.

The Drying Process. Where the method of salting is not employed, the next process is that of drying. Where the skins are "cased" or "round"—*i.e.*, obtained by method 2 and 3 above—they are dried with the fur inside. If "open"—method 1, above—the skins are merely spread open, pelt uppermost. It is during this drying that a certain number of skins become "burnt," owing to great heat, or sometimes on account of "taint" present in the skin. When a skin is "burnt," the pelt is converted into a very hard, horny substance which resists all subsequent attempts to convert it into leather. Some skins seem much more liable to this burning than others; for example, one frequently finds burnt patches in bear, wallaby, and marmot; more rarely in fox, sable, squirrel, and such-like small skins. Seals are cured with salt, laid in piles, and after remaining in the salt for about fourteen to twenty-one days, are corded up in rolls and shipped. Ordinary dried skins are packed in bales, fur to fur if "open," pelt outwards if "cased," though naturally the exact modes of packing differ according to the kind of skins and the customs of the district from which they come.

The first operation necessary for the conversion of the skin into leather is the one known as *fleshing*. The skins are first treated with water—sometimes with a weak brine—allowed to remain a certain length of time in order to become soft, and then the surplus fat and connective tissue removed by pulling them over a knife of the type shown in 2.

Grease Dressing. The skins are then ready for the next operation, which is that of *greasing*. For this purpose, grease of special nature (English dressers generally use animal oils, while in France colza and other vegetable oils are employed) is smeared over the pelt, allowed to soak in, and then the skins are subjected to a process by which the fats are driven into the substance of the pelt, rendering it soft and pliable. This is accomplished in one of two ways, according to the nature of the pelt. For small skins and such as possess a tender pelt the process of *foot tubbing* is employed. The skins, thoroughly greased, are placed in tubs inclined at a slight angle to the vertical, in which men with bare feet stand. By a continuous up and down motion of the feet the skins are constantly turned over and over, the grease is worked into the substance of the skin, and the result is a soft, supple pelt. During this process, a certain amount of heat is developed by the constant friction, and this in no small measure helps towards the accomplishment of the object in question.

3. DRUM FOR CLEANING SKINS

4. SHEEP SKIN DRYING IN FRAME

5. SEAL SKIN DRYING IN HOOP

In the case of skins having a stronger and heavier pelt a different method is employed. After greasing, they are placed in a mill which consists essentially of a box into which a wooden block descends. This block is attached to the end of a lever, and the whole is so constructed that the skins receive a hard blow at the moment of the fall of the lever, and at the same time are pushed slightly away from their former position. Here, again, a turning is effected, and the amount of heat developed is quite considerable. This method is the one always followed for heavy skins, such as seals, bluebacks, wallaby, etc., and is, of course, more economical than the slower process of tubbing. As might be expected, the length of time taken in each of these operations varies enormously. In some cases the skins are greased again, and the leathering process repeated. No definite rules can be given; the judgment of the dresser alone can decide when the skins are sufficiently leathered.

Removal of Excess of Grease. The skins at this stage are very greasy, and require careful cleaning before they appear in any way presentable. The chief substance used as an absorbent for this excess of grease is sawdust, though other materials are used, such as plaster of Paris and French chalk. Some French dressers sometimes mix a small amount of fine sand with their dust in order to secure more perfect cleaning. The greasy skins are worked about in the dust either in the foot-tub or in a mill like the one described above, except that it is boxed in, and so has received the name of a *box-mill*. Finally, the skins are turned fur outwards, if cased, and the fur cleaned in a similar fashion in what is known as a *drum* [3]. A drum consists of a hollow cylinder of iron or wood mounted on an axle and capable of rotation about this as an axis. Into the drum are placed the skins and sawdust, or whatever the cleaning material used may be, and the drum caused to revolve for a varying length of time. To free them from dust, the operation of *caging* is necessary. The process is a simple one. They are placed in a wire cage, mounted like the drum just mentioned, and as the cage revolves the particles of dust are beaten out, and fall through the meshes of the cage.

Finally, the skins are *shaped*—that is, stretched so as to look somewhat natural in appearance, and, if necessary, the pelt *knifed*—that is, pulled over a knife similar to the one used by the flesher [2], in order to further soften it and to remove inequalities; beaten with canes in order to free the wool from felt and to make it free and

flowing, and any parts of the pelt which may be torn carefully repaired.

This, in short outline, is the process of grease dressing, but there are so many details to be carefully observed, and so many pitfalls for the unwary, that it is only after much experience that really good work can be obtained.

Other Methods of Dressing Furs. Many other methods of dressing are in vogue. For example, the white Russian and Siberian hares come to this country in the dressed state; the leather, which is not by any means good, is made by soaking the skins in a solution of alum to which barleymeal is added. On drying, the pelt is left white, and is covered with very fine dust—a mixture of alum and meal.

China goods, such as goats, Thibet lamb, and kid-crosses are native-dressed with Glauber's - salt and rice flour. This, like the Russian method, does not give a leather which is at all to be compared with that obtained by grease dressing.

Much of the German dressing is done by a quick process involving the use of sulphuric acid. For certain skins this method seems peculiarly well adapted, though for others the results are interior to those obtained by the grease method.

The dressing of long-haired sheepskins is usually done with alum and salt. The skins are first scoured with soap and soda to remove grease, the pelt is scraped with various kinds of knives—*e.g.*, beaming knife [**1***a*], and then a solution of alum and common salt is rubbed into the pelt, this last-named operation being repeated several times. The skin is then stretched out in a *frame* as shown in **4** and allowed to dry slowly.

Fur Seal Dressing. In the case of fur seals of all kinds the procedure is somewhat different, and is as follows: First of all, the thick coating of fat is removed by what is known as *blubbering*. The skin is laid, pelt uppermost, on a *beam* similar to the one used by the unhairer [**6**], and the fat scraped off with a special kind of knife—a blubbering knife [**1***f*]. After this the skins are washed in a warm solution of soap and soda to get rid of grease from the fur, and they then undergo the process of *hooping*. This consists in stretching out the skin in an oval iron hoop by means of string passed alternately through the edge of the skin and round the hoop. Figure **5** shows a seal in the hoop. Next follows the process of *unhairing*. As previously explained, the fur seal possesses a beautiful soft under-wool and stiff upper hairs. By wetting the fur and then drying quickly these latter are so much loosened as to be easily removed by means of an unhairer's knife. The skin is placed over a beam, and the hair removed by a pushing motion of the knife. An unhairer is seen at work in **6**. Even after this some hairs are left, and to get rid of these a pulling knife [**1***e*] is used. The hair is caught between the blade and thumb and pulled out. This process of pulling is usually employed in dealing with otter, beaver, and nutria.

6. UNHAIRER AT WORK

7. SHAVERS AT WORK

There are probably no trade secrets so jealously guarded as those of the fur dyer. The particulars of the composition of various colours and dye-baths are known only to a very limited number, and these particulars are handed down from generation to generation with such modifications as are of necessity introduced.

The principal centres of this industry are London, Leipzig, and Paris, though the work is also carried on to some extent in various towns in France — *e.g.*, Lyons—in Belgium, and in America.

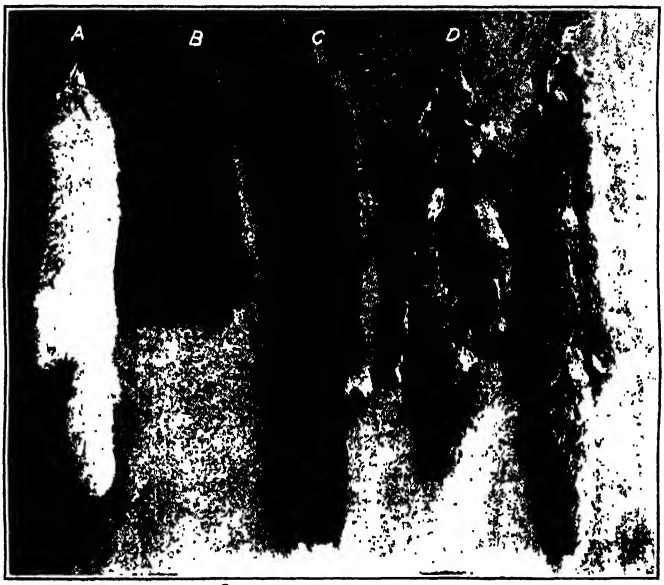
Materials Employed for Dyeing Furs. When it is remembered that the majority of the furs used in every-day life are of very sober appearance — black, sable, brown, etc.—it is easy to see that the wide range of colours obtainable by the use of dyestuffs derived from coal-tar products is useless to the fur dyer. He may require blues and reds and yellows for shading purposes, but to all intents and purposes, it will be seen that the so-called aniline dye industry derives but little support from him.

Nor is the limited choice of colours the only explanation of this fact. Most artificially prepared dyestuffs are only taken up from solution by the animal fibre at a temperature approaching the boiling point of water. Such substances are useless for dyeing furs, because, not only would the fibres themselves be injured at such a temperature, but the pelt would lose its supple nature and become hard and horny, and so worthless from the furrier's point of view; and, further, the hair and wool would become loosened, and readily detachable from the leather. In consequence, the dyer of furs must choose such substances as will be absorbed by the fibre at a low temperature—that is to say, not higher than about 50° C. Amongst such dyestuffs, those of natural origin occupy the first place, and they are therefore largely used. Blacks are obtained by means of

logwood and various metallic mordants, such as chromium, iron and copper; blues with various materials containing tannin substances, such as galls and sumach; yellows and browns with cutch, gambier, and turmeric. In addition to these other dyes are used for special purposes and for obtaining shades of colours.

Preparations for Dyeing. The covering described generally as fur consists, as previously stated, of two parts—the wool lying at the bottom next the pelt, and the stiffer upper hair. The outer covering of a hair is composed of a substance known as keratin, which is of a similar nature to the materials which go to make up the outer layers of the skin, nails, and hoofs. This possesses to a high degree the property of resisting the action of dyestuffs, and as it forms a layer which is very impenetrable, the colouring matter reaches the medulla of the hair only with difficulty. Consequently, before the hairs can be made to take up colour, this layer must be softened, so as to become more absorbent and to allow of the passage of the dyestuff into the medulla.

This object is achieved by a process known as *killing*. The killing is applied to the tips—in some cases to the wool as well—by means of a feather or a brush, and is usually of an alkaline nature, such as lime, soda, etc. As a result of this application the fibres are softened, and so more readily take up dyestuffs. Then follows a process known as *mordanting*. The skins are either brushed with or dipped in a solution of the mordant, the composition of which varies with the shade of colour required and the dyestuff subsequently used. Logwood, for example, is a polygenetic dyestuff—that is, with different mordants, different colours are obtained. Thus, with alum mordants, greyish violet shades are obtained: with chromium, iron and copper mordants, grey to black is the resulting colour; while tin mordants yield reddish violets. The principle underlying this process of mordanting is this: Certain metallic salts are absorbed by the fibre, and as a result of decomposition in and on the fibre—*e.g.*, aluminium acetate—or of oxidation—*e.g.*, ferrous salts, a *mordant*, usually a hydrated oxide or a basic salt, is formed. This mordant possesses the property of combining with dyestuffs to form *colour lakes*, to the presence of which in the fibre the final colour is due. It is usual to allow goods that have been mordanted to remain exposed to the air for some time before they are put into the dye, to allow the above-mentioned decomposition to take place.



8. SPECIMENS OF FOX
White fox *b.* Jap fox *c.* Kamchatka red fox *d.* Cross fox American red fox

The Dyeing Process. After mordanting the goods are ready for the dye. This is either applied with a brush, or the skins are immersed in the dye-vat and allowed to remain for such time as previous experience has shown to be necessary. In some cases the skins may be dipped twice or even four times, a definite period being allowed between each dip, during which time the skins are allowed to air. By this means oxidation takes place and the colour becomes fixed.

In using some materials—*e.g.* logwood—a different method is occasionally adopted. Instead of mordanting and dyeing in separate baths, one bath is made containing the mordant and dyestuff together. This, however, is not a common practice, as there is a considerable loss of colouring matter on account of combination between mordant and dyestuff, whereby the insoluble lake is precipitated, and has no opportunity of being fixed upon the fibre.

Of recent years a new class of dyestuff suitable for fur dyeing has been placed upon the market. These substances are chemical compounds prepared from coal-tar products, which on oxidation yield insoluble matters varying in colour from light brown to black. Some of them are exceedingly useful to the dyer, though for some purposes they are much inferior to the natural products.

How to Apply the Dye. In the dyeing of certain classes of skins it is advisable to apply the colour with a brush rather than by dipping them into a dye-bath. This is well illustrated in the case of the fur seal. On examination of the fur of a sealskin jacket, it will be seen that the colour of the lower part of the fur, or the *ground*, as it is called, is of a deep brown colour, while the top is much darker—almost black, in fact. This result is attained by brushing the fur with mordants and colours to different depths. That is to say, several brushings are made to a fixed level—care being taken that the same level is reached at each operation—with one mixture, and later another mixture is applied to the ground. The latter application produces a different colour where the fur has been previously treated, and so a distinction between *top* and *ground* is produced.

In the case of sable, marten, fitch, and such like skins, a large number is found in which the upper hairs or *tips* are too light to be quite pleasing. To correct this defect, and to accentuate the natural dark stripe which runs down the centre of the back, colour is carefully applied by means of a feather or a

light pad, this process being known as *tipping and striping*.

Beaver and nutria are skins which, after *pulling*, or removal of the top hair, are frequently *silvered*. This operation of silvering consists in the light application of various substances, which produce a lustrous appearance and considerably enhance the beauty of the skins.

Imitation Furs. Apart from the improvement in colour of natural skins, there is another branch of the fur-dyeing industry which is of great importance. This is the dyeing of cheap kinds so that they resemble to a certain extent the more costly furs. Enormous numbers of white Russian hares are dyed to imitate sable, Russian sable, stone marten, etc.; marmot are dyed sable colour; white fox and red fox are made to look like blue fox and silver fox respectively. Of course, it is only in the colour that there is any resemblance between the real and the imitation fur. One can no more make a Russian sable out of a white hare than the proverbial silk purse from a sow's ear, but to the uninitiated there is no very obvious difference in appearance between a jacket made of electric seal, which is only the common rabbit worth, say, five guineas, and a seal-skin jacket worth, perhaps, ten times the amount.

9. SPECIMENS OF HAIR SEALS
a. Whitecoat *b.* Blue-back *c.* Common Seal

After dyeing, all skins must be carefully dried and cleaned to get rid of any mechanically adhering dyes. When taken from the dye-bath, they are allowed to drain, washed in clean water, again allowed to drain, and the excess of moisture got rid of by means of a hydro-extractor, which is merely a cylinder with perforated sides revolving at a high rate of speed about a vertical axis. The centrifugal force causes the water to be driven outwards, and the skins are then partially dry. The drying is completed in drying-rooms or stoves heated by steam-pipes, and here great discretion is required, as, if the heat is too great or the process too hurried, both pelt and fur may be injured in quality, and the latter in colour. In order that they may dry flat, some goods are *nailed*—that is, placed on flat boards and nailed round the edges after a moderate amount of stretching. Others are merely stretched and allowed to dry slowly. To some, it is advisable at this stage to apply substances which keep the pelt soft and supple on drying, but this is not necessary in all cases, as much depends on the manner in which the skins are first dressed.

When dry, the skins are cleaned. This is accomplished by placing them in sawdust in a revolving drum of the type previously described. The length of time during which they must be *drummed* varies enormously, and depends largely upon the nature of the materials employed in dyeing. For some skins one hour is sufficient, others require twenty-four hours or even longer. When judged to be clean they are *caged* to remove the dust, and then passed to the finishing department. Here they are beaten with canes to free the under-wool from felt, the pelts damped, and the skins stretched and *knifed*—that is, pulled backwards and forwards over a blunt flesher's knife. This softens them, and makes them pliable, so that the fur lies evenly and "flows" under the hand.

Finally, the fur is *set*, or brushed with a damp brush in the proper direction, so as to straighten any hairs that may have got twisted and laid out of position.

Here the dyer's work comes to an end. From him the skins pass to the merchant, who disposes of them to the furrier, or direct to the furrier, who makes them into the thousand and one articles for which there is a demand

There are several processes used by the fur dresser and dyer which have not hitherto been mentioned. Some of the more important ones will be here described.

Shaving and Sleeking. The pelts of some skins intended for use as garments are so thick that unless a portion of the leather is removed the finished article would be uncomfortably heavy to wear. To remedy this defect the pelt is *shaved*. To perform this operation the skin is laid over a shaver's beam, which is similar to that employed by the unhairer, except that it is flat instead of being convex outwards, and by a series of downward pushing strokes layers of leather are stripped off, and the whole brought to a level surface of even thickness. To do this the skins must be sufficiently moistened, and the knife used of a special kind. Figure 1*h* shows one of these cross-handled knives. The edge is turned backwards and kept very sharp.

In 7 two *shavers* are seen at work on dyed whitecoats. The pelt, before shaving, is discoloured by the dyes used, and where the knife has passed over the pelt the white unstained leather is to be seen. Each shaver holds between the first and second finger of his right hand a small steel [1*c*], with which he sharpens the turned-back edge of the knife.

Various mechanical contrivances have been devised with a view of replacing this manual work, but so far no process causes so little damage to the skin or gives such a good result as this one just described. All seals, including fur seals, bluebacks, hair seals, and whitecoats, are shaved, and sometimes heavy-pelted skins like wallaby undergo the same treatment.

Sleeking is a process adopted in order to soften and make smoother the skins which are dressed with a heavy pelt such as goats. The skin is laid out, pelt uppermost, upon a flat table, and the *sleeking knife* [1*d*] pushed over it. Inequalities are removed, and the friction also causes a certain amount of softening.

In fur seals, after dyeing, there are to be seen short, stiff hairs which escaped the unhairing and pulling knives. These, if allowed to remain give to the skins an unpleasant *handle*—that is to say, they feel harsh when the hand is passed over the fur. In order to remove these, various types of machines have been devised. One of the earlier instruments was so constructed that the skin was stretched over a bar, the fur blown back and held down while the stiff, upstanding hairs were burnt out at the roots by means of an electrically-heated wire. In a later and improved pattern the hairs, instead of being burnt out, are cut off by the scissor-like action of two blades which are moved after the fur is blown downwards and held in position by two combs. By a system of gearing the skin is caused to move forward a fraction of an inch immediately after the release of the blades from the cutting position, so that every part of the skin is in turn subjected to this process.

Even then, certain hairs, known as *stage hairs*, are left, and these are removed by a pulling instead of a cutting action in a machine of somewhat similar construction, known as a *stageing machine*. The process of machining is essential for many skins, though there is an unavoidable removal of some of the fur which tends to make the skin poorer in quality.

Shearing. For some purposes, such as the manufacture of glove tops, fur for covering ladies' hats, etc., it is usual to take certain kinds of skins and by shearing off the top hair secure a shorter fur with an even surface. This is largely done in the case of white Polish rabbit, Russian hares, and some skins which, when dyed and shorn, resemble furs of a shorter staple.

The skin is fastened to an endless band in the shearing machine which passes over rollers. The tips of the hair come against a knife over which passes a set of blades set round a cylinder. This cylinder revolves at a high rate of speed and cuts off the tips exactly as grass is cut by a lawn-mower. Attached to the machine is a pipe connected with some arrangement for creating suction, by which the loose fur is carried away.

In addition to these processes there are others which are of use in various departments. For example, some skins can be mechanically brushed and beaten, and in such cases manual labour is dispensed with.

In connection with the subject of the dressing and dyeing of furs, it must be remarked that there are probably few branches of industry where experience counts for so much as in this one. To become a successful dresser, and perhaps still more so in the case of the dyer, great patience must be exercised in the acquiring of details concerning the methods to be employed for each particular class of goods. No two parcels of goods can be treated in the same manner; each requires careful consideration and must be treated according to its merits. Unceasing watch must be kept lest at any one of the many stages mistakes should be made, lest skins should be kept too long in a moist state, or the drying should be hurried.

Formerly, as in the drying of textiles, rule of thumb methods were the fashion; but the old order has changed and is yielding place to new. Science, the handmaiden of all arts and industries, is beginning to take her rightful place, and in consequence new methods are being introduced, and better and more constant results are to-day attainable.

The Manufacture of Fur Articles.

From the fur dresser and dyer the finished skins pass to the furrier, whose work consists in making them into articles for personal and domestic use. This work may be divided into several divisions, and though an experienced furrier is capable of executing the whole of the work, most firms employ men for each department.

Let us suppose that a lady's sable set is required. The skins to be used are carefully sorted and matched according to colour. A pattern in paper is usually made and the skins laid over this in order to see how many are required. The furrier then cuts off legs, tails and heads, as well as any bad patches on flank or belly. Should there be small bare patches in the skin they are cut out, a V-shaped cut being made from the pelt side, and the edges again sewn together. In this process of cutting, a knife of peculiar pattern is used. One is shown in **1b**, and will be seen to consist solely of a blade. It is held with the blunt end in the hollow between thumb and first finger, by the thumb and second finger, while the first finger is curved over the blunted circular back of the knife.

It is necessary sometimes to match different parts of the skin. For example, in sewing together two sable skins, head of one to rump of the other, there would be considerable inequalities in the surface, so that it may be advisable to remove a portion of the rump in order to get a more even surface. Again, two skins, A and B, stitched side by side, may be of slightly different colour or fulness. Accordingly, they are cut down the centre of the back, the left-hand half of A is stitched to the right-hand half of B, then the remaining halves are sewn together and the two composite skins sewn as required. By this means a more even article, both in surface and colour, is obtained than would be possible if the skins were merely sewn together.

After cutting away all undesirable parts of the skin, and the process just described, the skins are sewn together. For this purpose a special machine is used. It consists essentially of a needle travelling horizontally, which just clears the surface of two circular discs or shallow cylinders placed in the horizontal plane and touching tangentially. These discs are kept together by a spring which can be released at the will of the operator. In using the machine, the two edges which are to be sewn are brought together between the discs above-mentioned and held there after any upstanding fur has been placed in position by means of a blunt needle or other object. When ready, the machine is set in motion—they are usually driven by a foot-treadle—and as the discs revolve, the skins travel on and the needle passes through both skins forming the stitch, and at the same time locking it.

"Nailing." When the various pieces are sewn together, the whole must be stretched so as to make the seams lie flat and to bring the piece to the shape required. To effect this, the process of *nailing* is necessary. For a flat article such as a tie or coat-lining, the skins are moistened on the pelt side, stretched out on a flat board, fur side downwards, and small nails driven in at the edges. For muffs a block is used, generally made in three pieces, which fit into one another by means of a tongue and groove. The skins are stretched round the block and nailed securely round the edges: sometimes several parallel rows of nails are also driven in in order to keep the skins straight.

The articles are allowed to dry on the nailing board or block and are then removed. Where a block has been used, the nails are drawn and the centre piece of the block taken out. This allows the muff to be easily taken off without altering the shape. Next comes the process of lining. Silk, satin or other material is employed, and between it and the fur a layer of cotton-wool or wadding is placed. This serves a double purpose, that of increasing the thickness and so making it more serviceable as a defence against cold, and also that of making the muff or other article feel *fuller* and softer than it would otherwise do.

Linings and Rugs. A large part of the furrier's work consists in the manufacture of fur linings for coats. The skins are matched as far as practicable for colour and quality and the processes of cutting and nailing carried out. Sometimes this work is done in the countries from which the skins are obtained—as, for example, the dog robes from China, or the kidcrosses and kidleg crosses from the same country. Marmot skins are occasionally made up into linings, which are sold under the name of marmot robes.

The chief furs which are made into linings are musquash, opossum, hamster, kaluga (or susliki), squirrel back and squirrel belly (or squirrel lock, as it is generally called), mole and mink.

Rugs are made from skins which are best adapted for the purpose for which required. Vicuna, guanaco, and raccoon are largely used for carriage rugs, while for hearthrugs, bear, wolf, goat, dyed either black or bear colour, and sheep skin, are most frequently used.

Seal Skins. In order to summarise the various processes which are necessary to convert a raw skin into a finished article, it will be convenient to take the sealskin as an example and to describe in their proper sequence the different operations which are performed.

The seals are killed either on the beaches or in the open sea. In the latter case they are sometimes speared, but it far more frequently happens that they are shot. When taken on land, care is required in the stages prior to the killing. On the Alaskan Islands the bachelor seals, or *holluschickie*, as the natives call them, of ages varying from two to seven years, are driven from the seal beaches to the killing grounds. This must be accomplished slowly, or the animals become heated, and the fur rubs away at the least touch. They are driven in herds, and on arrival at the place of slaughter are stunned by means of blows on the head delivered with heavy wooden clubs. A sharp knife is plunged between the fore flippers right into the heart, to kill the seal and to prevent further *blood heating*, as it is called. As soon as possible the animals are skinned, and every available piece of skin is removed and only little patches on the upper and lower lip and tail are left. The skins, with their thick coat of blubber attached, are taken to the curing house, laid in piles, fur to pelt, and salt plentifully applied to the flesh side. After remaining for about three weeks, they are rolled and corded, and sent for shipment, and it is in this state that they arrive in London. They are then sorted according to size and quality and put up for sale by public auction.

From the sale-room they pass to the dresser and dyer, whose work it is to change the unsightly objects into a presentable skin. The first work to be done is the removal of the fat or blubber, after which process the skins must be washed with various cleansing materials, then dried as already explained.

The "Unhairing" Process. The next process is that of *unhairing*. By damping the skins and quickly drying at a comparatively high temperature the hair is loosened while the fur remains unaffected. The unhairer then proceeds to remove all hair, as far as is possible, first with the unhairing knife, and then with his pulling knife.

At this stage the fur presents a curly appearance, and is yellow to grey-brown in colour. From the unhairer they pass to the dresser, who greases, mills and cleans them, and prepares them for the dyer. It is important that all grease should be removed from the fur, as if this is not done the dye is not properly absorbed and an uneven and patchy colour is the result.

On receiving the dressed skins, the dyer combs out the fur, and proceeds to apply the various mordants and colours. This is always done by brushing, because by this means the curl is taken out of the skin and also the pelt is less injured than if the skins were dipped in the dye liquor. Between each operation of brushing—and there are many of them—the skins are allowed to dry, and are then beaten to get rid of dust from the materials employed.

When the dyeing operation is completed, the skins undergo a thorough cleaning in sawdust to make the fur bright and soft, and to remove all traces of the dyestuffs from the bottom of the wool, where it is apt to lodge. This is necessary in order that the skins may feel soft and full to the touch. If dirty they feel somewhat harsh, and the fur does not flow easily when the hand is passed over it.

Preparing the Pelt. Attention to the pelt is now required, as it is thick, heavy, and almost black from long contact with colouring matters. To alter this state of things the skins are handed over to the shaver, who moistens them and then shaves down the pelt to an even thickness. In doing so, he takes off the outer discoloured layer and leaves the pelt almost white—generally tinged with yellow.

After drying, the skins are carefully examined in order to pick out any that require *machining* and *stayeing*. During these various processes, the fur may become slightly disarranged. Certain portions may be twisted, and, by the weight of skins above—they are always folded down the middle, pelt outwards, and laid in piles—*print marks* are produced. These spoil the appearance of the skin, and are got rid of by the process of *setting*. The fur is brushed with a soft brush, moistened with either plain water or a weak solution of various substances, and then allowed to dry.

The skins are now finished, and are sent back to their proper owners. The merchant disposes of them to the furrier, who proceeds to manufacture from them jackets, capes, or other treasures so dear to the feminine mind. The furrier, instead of employing his own permanent staff, may hand the skins to a *chamber-master*, who is required to make so many articles from the skins provided. This practice is less common than formerly, as most furriers prefer to have the work done under their personal supervision. The processes already described are employed, the skins are cut, nailed to shape, and the pieces sewn together. Then the lining and padding are added and the garments pass to the retailer, who supplies the public needs.

FURS AND FURRIERS *concluded; followed by* FEATHERS

BACTERIOLOGY

Varieties and Structure of Microbes. Their Life and Growth. How a Bacteriological Investigation is Made. Bacteria the Scavengers of Nature

Following TAXIDERMY from page 6329

By Dr. GERALD LEIGHTON

ONE of the principal factors in the causation of disease is the action of bacteria. In considering their office in disease we may learn something of the function of these minute organisms in various natural processes, and so gain at one and the same time a comprehensive, if brief, view of the whole science of bacteriology. It is one of the most modern of studies, dating from the invention of microscopes of immense magnifying powers, and the discovery of many methods of staining by means of aniline dyes. Without these means little could have been discovered about bacteria.

Terminology. First let us understand the terms used in describing the group of minute organisms under consideration, which take such a prominent place in modern scientific work and thought. Some of the terms used are popular but somewhat vague; others have a definite meaning in bacteriological science. Thus the terms "germs," "microbes," "micro-organisms," "bacteria," are used synonymously and rather loosely to refer to the whole group of these minute cells. The word *bacterium* really means a rod, but it is used in reference to all shapes of organisms, the term *bacillus* [3] being the one chiefly used to designate those of a rod-like shape. Other shapes of organisms have each their appropriate designation: thus the round cells are termed *cocci* [4] or micrococci, the curved ones are termed *spirilla* [7], these, with the rods or bacilli, being the most important shapes. When the small round micrococci are arranged in groups somewhat resembling a bunch of grapes, the whole cluster is called a *staphylococcus* [2]; when the micrococci are arranged in a chain they receive the name of *streptococci* [1]. A glance at the illustrations of these various shapes will make these terms perfectly clear.

The globular cells, straight rods, and curved rods constitute the lower micro-organisms, and are by far the most numerous kinds.

Size and Movement of Microbes. The lower microbes are minute masses of protoplasm, containing no chlorophyll, and are not more than $\frac{1}{25000}$ in. in diameter. Their outline is sharply defined as they are seen under the microscope when stained.

Germs are, of course, dependent upon their environment for being scattered about—winds, water, food, the circulation of the blood in the body, all acting as means of dissemination. But, apart from this general movement, they have special means of locomotion by means of which each individual changes its attitude and position—at least, some species have them. This movement is effected by means of fine, hair-like protoplasmic processes called *cilia* [6], which are attached to one or other end of a bacillus or spirillum, or to both ends, or to the sides, and by the lashing of these cilia the cell is moved in a liquid medium just as a boat is moved by oars. The position and direction of the movement of the cilia will determine whether the microbe darts, rolls, or simply vibrates. Organisms which possess the power of locomotion by these flagellæ or cilia are termed "motile," the rest being called "non-motile."

Reproduction. The great majority of the lower organisms reproduce themselves by the simple process of fission [see BIOLOGY, page 381, 6 and 7]. A simple constriction appears in the middle of the organism which eventually divides into two individuals [5]. In some species this process takes place rapidly, in others more slowly. Some will divide in twenty minutes. A simple calculation will show that even if the division occurs only once every hour, as many as 17,000,000 organisms will arise from a single pair in the twenty-four hours. For this to occur, the environment must, of course, be a favourable one as regards temperature, moisture, and nourishment. Such an environment for some disease-producing germs is found in the human body, and we can thus realise the rapidity with which an organismal disease may become serious and even fatal.

Effect of Environment. Thus, at the outset we see that, in order to check the ravages of pathogenic—that is, disease-producing—germs the physician must direct his attention to making the surroundings of the germ as unfavourable to reproduction as possible. Once in the body the only way to do this is by assisting the natural resistance of the person by suitable drugs, and especially by the special antibacterial or antitoxic substances which are rapidly becoming the most reliable means of treatment. Outside the body, in Nature, or in the artificial growths of germs in the bacteriological laboratory, the effect of environment is seen to be dependent upon the presence or absence of fresh air, moisture, certain gases, the degree of heat or cold, and the supply of nutrition.

The Food of Microbes. In Nature, germs live chiefly upon complicated organic substances, and upon the dead or living bodies of plants or animals, or in excretions. As a rule, a number of different species are found living together, and no doubt they are affected to some extent by this presence of neighbours. When one germ is grown by itself by a bacteriologist, it is probably in better surroundings than in actual natural life; it is better looked after. As a matter of fact, it is found that the fluids and nutritive media made from animal tissues suit their growth best. All germs need nitrogen in some form, as well as salts, such as chloride of sodium, sulphates, and phosphates. Some few require special elements, such as sulphur, in order to flourish. Most require to be in an alkaline medium; some, indeed, being unable to stand even a trace of acidity.

The Effect of Moisture and Gases. In order that continued growth may take place, moisture is absolutely essential. The resisting power of germs to dryness varies greatly, however, in different species. Thus, two to three hours of dryness kills the cholera germ, while that of diphtheria will stand much longer. Those which form spores can remain alive in the spore condition for a very long time, even years, although dry, but they do not actively reproduce in this resting state. They are in a condition

of suspended animation, ready to resume active life when a favourable opportunity occurs, but for the time being quiescent.

The influence of the presence or absence of oxygen is very marked; indeed, it supplies one means of classifying germs into two groups, according to their manner of reaction. Most can live in oxygen: indeed, require it. They are termed *ærobes*, or *ærobic* organisms. Some cannot live in the presence of oxygen, or can do without it; they are termed *anærobes*, or *anærobic* organisms. Many germs do not flourish well in the presence of carbonic acid gas.

The Effect of Temperature. Every organism has a special temperature at which it grows best (the optimum temperature), a temperature above which it will not live (the maximum temperature), and a temperature below which it cannot survive (the minimum temperature). The best, or optimum, temperature is that of its natural habitat. Thus, for the germs which induce putrefaction, the best, or optimum, temperature is that of warm summer weather (20° C. to 24° C.). For those which flourish in the tissues of animals it is from 35° C. to 39° C. For most germs the highest or maximum temperature is from 42° C. to 44° C., and the lowest or minimum temperature from 12° C. to 14° C. Some exceptional germs will live up to 70° C., and others as low as 5° C. The optimum temperature for most of the microbes which are active agents in the production of disease is, as would be expected, about the same as the temperature within the human body.

The Study of Microbes. In order to study the life-history of any given microbe a good deal of training in laboratory methods is required, together with much practice in the use of high-power microscopes. It is not our purpose here to enter into minute details of bacteriological work, but it is of interest to learn a little concerning the methods of investigation which have yielded such immensely important results in the science of health and disease. Some of these methods are highly technical, but certain general principles underlie them all, and it is to these we may direct our attention.

Suppose, in imagination, that we are fortunate enough to be allowed to watch all the proceedings of an expert bacteriologist in his laboratory. He is about to make an investigation of the microbes contained in a specimen which has been sent to him, concerning which a report is wanted by the public health authorities or some other body. He is about to ascertain what germs are present, if any, in the specimen of water, food, discharge, or organs (whatever the specimen may be), and we are at his elbow watching all his doings. How does he set about such a task?

In the first place the investigator, being absolutely ignorant of what he may find, keeps constantly in mind the fact that every precaution must be taken to prevent accident to himself or to others in the laboratory. Many microbes are extremely dangerous to work with, and a good many scientific bacteriologists have lost their lives in this kind of experimental work. The microbic enemy is invisible, but of deadly potency, and so minute is its size that the slightest scratch upon the skin of the investigator will suffice for the germ to make an entrance into the tissues under the skin, which may be followed with fatal results. The bacteriologist, therefore, first of all, protects his hands by soaking them in some strong antiseptic solution which will kill any germ which may happen to lodge thereon. If the specimen to be examined be a carcase or a body he will put on special indiarubber gloves for the first part of his task, gloves which, while they are impervious to the passage of germs, do not interfere with the movements of the fingers. But his precautions do not end with his own hands. The greatest care is taken to see that every instrument and all kinds of apparatus which come in contact with the suspected material is likewise sterilised by boiling or heat both before and after use. Thus, if it be necessary to cut the specimen with a knife, the blade is first passed through the flame of a Bunsen burner and again passed through the flame before the knife is laid upon the table. In this way no germs from the specimen are allowed to contaminate the laboratory.

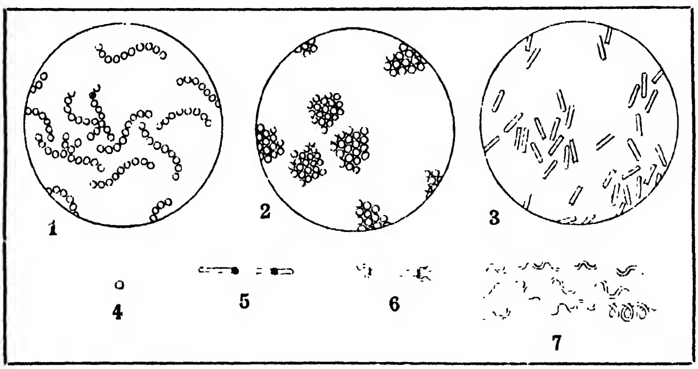
The Examination of Microbes. The bacteriologist, having taken all these and other similar precautions against possible mishap, now proceeds to find and examine the microbes present in the specimen. Two methods of examination are open to him, and he generally avails himself of both. In the first place, he may prepare a "slide" for examination under the microscope, which will reveal the presence or absence of microbes, and, if treated by special staining methods, may enable him immediately to say whether certain species of microbes are present or not. The microscope will show the relative abundance or otherwise of the germs, their shapes, their sizes, and their relation to the tissues in which they are lying. In certain diseases, such as anthrax, an examination of suspected blood by means of the microscope and a stained slide, may be completed under half an hour and a definite diagnosis given. In other cases, however, the microscope may reveal the fact that large numbers of germs are present, all mixed together, and it may be impossible to say what these are, or to which the condition is due, until they have been separated from each other and examined one by one. The investigator then proceeds to the second method—namely, that of separation of organisms and their artificial growth in the laboratory. He "cultivates" the microbes, on suitable media or soils specially prepared for the purpose.

Cultivating Microbes. The nutritive media in the laboratory are some solid and some liquid preparations. Without entering into the details of their preparation it may be noted that they are all devised to supply food for the growth of the different germs, and to provide convenient methods for the observation of the germs while they are growing. The more generally used nutritive liquids are bouillons or broths, milk, the aqueous humour from the eye of animals recently killed, and blood serum. The best broth is made from the flesh of bullocks, finely minced and freed from fat, mixed with filtered water, with a little common salt added, and the whole rendered slightly alkaline by the addition of some carbonate of soda. The resulting broth is poured off into test tubes and sterilised by heat to make sure that no living germs are left in the broth from extraneous sources, otherwise these would at once begin to grow. The tubes are sealed up with cotton wool, which prevents the entrance of organisms from the air by acting as a fine filter, and they are then ready for use by making "inoculations" into them. The test tubes or flasks are themselves sterilised first, as are all the implements and apparatus used in these investigations. All that is necessary now in order to cultivate the germs is to introduce some of them into the sterilised flask containing the nutrient medium. Their subsequent growth produces definite appearances in

the medium which can be watched and which are characteristic of the various species.

Separation of Germs. But here arises one of the many difficulties in bacteriological work. If the suspected specimen contained but one kind of microbe, all would be well. A portion of the specimen introduced into the flask would then give rise to a growth of the one organism present, which could be studied at once; but this is rare. As a rule, many microbes occur together; all sorts and sizes of germs flourish in Nature under the same conditions, some of them disease producers, others perfectly harmless. Before the appearances of any one of these can be studied in a culture, it must be separated from all the others and grown by itself in its own tube or flask. This is what is termed "making a pure culture," as opposed to a "mixed" culture, which contains two or more species of microbes.

A Pure Culture. To overcome this difficulty of the mixture of microbes resort is had to the use of solid media for cultivations instead of the liquids mentioned above. These solid media have a similar basis of meat extract as the real food on which the organism flourishes, but to this is added some substance of a stiffening nature, which, when the medium is cooled, renders the whole mass solid and firm instead of liquid. The two substances generally used for this purpose are gelatin and agar-agar, the latter being prepared from the roots of Chinese seaweeds. In other words the ordinary liquid medium is gelatinised. It is further rendered free from opacity and made quite clear and transparent by the addition of the white of an egg, the result being a beautifully clear, solid medium which can be poured into test tube when warm and left to solidify in any shape desired by merely sloping the tube in the direction required. It can also be poured into flat dishes or on to plates having a broad surface.



COMMON FORMS OF BACTERIA

1. Streptococcus 2. Staphylococcus 3. Bacilli 4. Coccus 5. Bacilli with s 6. Bacillus with cil 7. Spirilla

With these at hand the bacteriologist can proceed to isolate the different microbes in his mixture. The first point is to get the mixed germs as far as possible apart from each other so that when they are allowed to grow upon the nutrient gelatin each single germ will give rise to a small colony of its own species uncontaminated by any other species. A drop of the suspected solution or a minute portion of the suspected material is introduced into a tube of this sterilised melted nutrient gelatin and thoroughly shaken up so as to separate the contained germs. A glass plate, having been previously sterilised, is placed upon a perfectly flat surface and on to this the melted gelatin, with the organisms scattered through it, is poured. This is allowed to cool, carefully protected from contamination from the air, and as it cools the gelatin solidifies. This fixes each organism at a given point where it starts growing, either at the ordinary room temperature, or in an incubator in which the temperature can be raised as required. In the course of a day or two small points are observed to appear in the gelatin, each of which represents a colony of one species of microbe. Each one of these separate colonies can now be inoculated into nutrient gelatin in separate tubes, so that finally the investigator has got a number of germs growing in pure cultures. They are inoculated by picking off a minute portion of the colony on the plate with the point of a platinum needle which has been passed through the Bunsen burner or other flame first, and the minute portion thus taken is plunged into the solid gelatin in a tube, or simply stroked along a sloping surface of gelatin similarly in a tube. In the one case we get a "stab" culture, in the other a "stroke culture." The former grows down into the gelatin along the course of the needle track, the latter merely on the surface of the gelatin, also along the track of the needle stroke.

It need hardly be pointed out that if it be suspected that there are great numbers of organisms present in the original matter to be examined, these can be diluted to any extent before pouring the finally separated organisms on to the plate.

Characteristic Growths. Now the bacteriologist has got his germs growing in pure cultures, and their bacteriological characters and their methods of growth can be noted at leisure. Among the most important points which are ascertained by means of such pure cultures the following may be mentioned.

When grown on these solid media some organisms cause a liquefaction of the gelatin, others do not; some produce gas (ærogenic), others do not; some produce colour (chromogenic), others do not; a few are phosphorescent (photogenic); whilst those which are disease producers are termed "pathogenic."

In addition to the purely biological method above described, much information has been gained concerning germs by the experimental method of making inoculations into living animals. This applies especially to the pathogenic germs, and it is by this method that bacteriologists have been able to produce the antitoxic serum which is so successful in the diagnosis and treatment of some microbic diseases.

Proof that a Germ Causes a Disease. Before the bacteriologist is justified in asserting that the cause of any given disease is *proved* to be due to any given germ, the following results must be obtained:

1. The said microbe must be present in every case of the disease.
2. The said microbe must be isolated from the body and cultivated as a pure culture.
3. The said microbe, if inoculated into an animal, must produce a condition similar to that from which it was separated.

4. The said microbe must be again separated and cultivated from the diseased animal into which it was inoculated and in which the disease was produced.

This is what science calls proving a question, and in those diseases which are now known to be due to special forms these four tests of causal relationship have been repeatedly carried out.

So much for the general principles of bacteriological investigation and the isolation and cultivation of these germs. We may now turn for a moment to a brief consideration of the general place in Nature occupied by these minute agencies, for their functions are by no means merely those of destructive agents in the production of disease.

Bacteria in Nature and Commerce. In the early days of the science of bacteriology, only a few years ago, there was considerable uncertainty as to whether these multitudes of organisms which occurred everywhere in earth, air, and water, did so as a mere accident, or whether their presence was in any way essential. We now know that they are an absolute necessity for the carrying on of a large number of the most ordinary everyday occurrences of Nature. For example, all the processes of fermentation are microbic in origin, and so also are the processes of putrefaction. The lactic acid fermentation of milk, which is so common, is due to the action of microbes, the sugar of the milk being broken up and lactic acid produced. In the ripening of cheese, the resulting flavour is due to products of bacterial action. Another fermentation, the study of which is applied to the commercial manufacture of vinegar, is also due to microbes, and here alcohol is converted into acetic acid.

In the various brewing processes bacteria play a very important part, especially in interfering with the excellence of the products of the manufacture. The various conditions of bitterness, muddiness, abnormal colours, and so forth, are all microbic in origin, and all associated with some form of acid production. Most of these organisms are easily killed by heat.

In the everyday work of baking some of the starch is converted into sugar by the action of the yeast organism, and this sugar in its turn into alcohol and carbonic acid gas, to the latter of which the "rising" of the bread is due. The subsequent operation of baking serves the purposes of killing the ferment, fixing the starchy food in position, and driving off the alcohol and carbonic acid gas. In like manner certain faults in bread are due to the presence of unwelcome germs.

Bacteria as Scavengers. One of the useful qualities of certain microbes is that of being able to break up complex organic matter into much simpler substances, and it is now recognised that bacteria act as the scavengers of Nature by thus acting upon dead animal or vegetable matter. This takes place not only out of doors, but also in the alimentary canal in the human and other animal bodies. A special organism termed the *Bacillus subtilis* produces many of these changes. It is found in all putrefying fluids along with other organisms which also help in the process of disintegration. These putrefactive organisms, therefore, play a very important part in the economy of Nature by keeping up the circulation of matter, making the excretions of plants and animals, as well as their dead carcases, available once more for the nutrition of others. Germs thus convert organic matter into inorganic substances. In Nature this process goes on on the surface of the soil or near the surface and in the presence of the air. The organic matter lying there is oxidised and so made ready for the nutrition of plants. In fact, it would appear that this process of microbic oxidation is absolutely necessary, and that if the soil be made sterile or free from organisms it would be incapable of furnishing enough nutrition for plants to grow at all well. The organisms which do this work need the presence of oxygen for their active growth, and from this fact they are termed *ærobes,* or ærobic organisms.

Germs in the Deep Earth. But in addition to these superficially living germs there are others, which work at greater depths, out of contact with the atmosphere—that is, with oxygen—and which are termed *anærobes*, or anærobic organisms. They have the faculty of wresting oxygen from the substances containing that element which come down to them from above, using some, and freeing the rest for purposes of oxidation, thus helping on the decomposition of organic matter. This material, when freed from its oxygen, is of no further use for nutrition, and hence deeper still we find no organisms at all, this depth varying with the nature of the soil, but being commonly stated as being about 12 ft. from the surface. The bearing of these facts upon the purity or otherwise of water supplies drawn from surface sources, or deeper ones, is too obvious to need further comment.

Contamination of Water. It is thus evident that water taken from near the surface must contain a certain number of germs, and if there be organic matter on the surface putrefactive germs will be there too. Matter from under the soil surface is usually free from the putrefactive germs, but has some peculiar to itself, while deeper still, water will be obtained free from microbes altogether. It does not follow, however, that water taken from a depth must of necessity be pure and fit for hygienic purposes, because there is always the risk of such water becoming contaminated before it reaches the consumer. It is a very simple matter for a disease-producing microbe, such as that of typhoid fever, to contaminate an otherwise pure water supply.

Suppose that a case of this disease exists in a given locality, the organisms of the disease are present in numbers in the intestines of the patient, and pass out with the excreta. Now, unless these excreta are disinfected and the microbes killed, the microbes simply pass into the drains or on to the surface of the soil, according to the disposal of the sewage. The organism grows and multiplies, and sooner or later finds its way into the water supply of the district, and thus spreads the disease, perhaps, to many people, causing an epidemic. Milk pails and cans may similarly be easily contaminated from one case.

From what has been said of the action of the microbes in the earth and the part they play in breaking up organic matters and rendering them fit for the food of plants, it will readily be recognised that the processes of agriculture are dependent ultimately upon the action of bacteria. This is an actual fact.

Fertilising Bacteria. The uses of all the manures which are applied to the enriching of land depend upon these bacterial processes. The various changes undergone are collectively spoken of under the general term of *nitrification.* All the compounds in dung, manures of various sorts, dead carcases, plant tissues, and so forth, when spread over or dug into the earth, become oxidised, and ultimately a large part of the nitrogen from these becomes converted into

nitrates of calcium or potassium. This nitrification process will not take place in a soil which contains no bacteria, hence germs are essential in agriculture. The process is illustrated diagrammatically on a previous page, to which reference should be made at this point [see page 277]. It will be noticed there that the process has two stages: first the partial oxidation into nitrites, then the further oxidation of these into nitrates. No one germ is capable of doing the whole process as seen in the diagram, two sets of organisms carrying out the two stages. Both kinds of germs are to be found in manure heaps, sewage, and soils, and both require the presence of oxygen and water for the performance of nitrification. It follows that their work is interfered with in extremely dry soils, and a temperature below 5° C. or 6° C. inhibits their activity. For the further and more detailed study of the value of artificially prepared manures, that is to say manures ready nitrified, the reader should consult the course on AGRICULTURE.

Useful Work of Bacteria. The bacteria which feed upon dead organic matter are called *saprophytes*, in opposition to those which live in or upon the living organic compounds composing the tissues of animals or plants, these germs being termed *parasites*. Many of the latter are disease-producers: many of the former are very useful agents in various natural and artificial processes. The saprophytic species are of greater importance to the farmer, for, as we have explained, they are the active agents of putrefaction, and they render carcases and dead plants available for the nutrition of living plants. To these saprophytes also are due the processes in the ripening of cheese, the nitrification of manures, and many chemical changes included under the general term of fermentation. These latter changes result in the production of certain definite compounds which are essential in the special processes concerned. Thus, the "lactic bacteria" are useful in cheese ripening. In order to be sure of the presence of these germs a little sour milk is added to the sweet cream, or the cultivated bacteria themselves may be used.

If beer or wine containing less than 14 per cent. of alcohol be left exposed to air for a few days the surface becomes covered with a tough, whitish film, and the beer or wine goes sour. The film contains numbers of bacteria which produce acetic acid from the alcohol. This process is the basis of the manufacture of vinegar from fermented malt liquors or fermented grape-juice.

Bacteria and Milk Products. Two milk products in which bacteria are active agents may be mentioned here. One is known as *koumiss* or kumiss, an intoxicating beverage made from the soured and fermented milk of mares. It has an acid taste,and is much esteemed by the Kalmucks, the most numerous of the Mongol nations. A spirit is made from the koumiss by distillation, and since it is said that the tribes which are addicted to the use of koumiss are free from the ravages of consumption, the use of an artificial koumiss has become fairly general. This preparation is made from milk of asses or cows.

The second of these products is termed *kephir*, a drink used in the Caucasian districts, which is also made from milk. In the process the casein is dissolved, and the milk sugar is acted on as in a lactic acid and alcohol fermentation. The masses of bacteria which cause this process are called kephir grains.

Koumiss, or fermented mare's milk, has been used with an undoubted degree of success in the treatment of consumption in Russia. The secret of the success is that the milk is slightly fermented, highly digestible, and hence large quantities can be taken without producing dyspepsia. It is really an invalid food. In Russia the mode of treatment is for the patient to rise early and drink a glass of koumiss every half hour, excepting the two hours just before dinner and supper.

Artificial kephir, prepared from cow's milk, is made as follows. The milk is as new as possible. A bottle is nearly filled with the milk and some water, and to this are added some yeast and a lump of sugar. The bottle is tightly corked and the cork wired down, to prevent escape when fermentation occurs. It is placed in a warm spot and shaken two or three times a day for from four to six days. The bottle must be carefully opened to prevent much being lost, as it is very effervescent.

Both koumiss and kephir are more easily digested than ordinary milk. In both the casein-forming material is thrown down in a finely flocculent, easily digested form, already partially peptonised. Most of the sugar is turned into lactic acid; a little alcohol is produced, and a good deal of carbonic acid gas. These two preparations, therefore, present milk in its most easily digested shape; hence their value as invalid foods in dietetics.

These milk products are good examples of processes dependent upon bacteria, which are not merely harmless, but of the greatest service to mankind.

Bacteria and Water. The relationship of bacteria to water is a matter of profound importance, inasmuch as water is perhaps the most convenient method of carrying germs from place to place. Thus, after rain the air is wonderfully free from microbes, which have been carried down on to the ground. Stagnant pools and slow streams —in fact, surface water of all kinds—always contain large numbers of microbes, the numbers and their species differing greatly according to the nature of the soil, the depth of water, and the degree of oxidation going on. The less the water is disturbed the more numerous the germs. In spring water few or no germs occur until contamination happens at the surface. In examining water for bacteria the sample should be examined immediately it is obtained, for the simple reason that if there be any nutriment in the water the germs therein, however few to begin with, will soon multiply with great rapidity and thus give a most fallacious result if left for any length of time. "If a sample of even the purest water (containing, say, 200 germs per cubic centimetre) be left to stand in a room in which the temperature is comparatively high, and therefore suited for the rapid growth of these organisms, it may be found that in place of 200 germs per cubic centimetre, there may be present on the second day 5,000, on the third day 20,000, whilst on the fourth they are almost innumerable."

Continued

Group 22
MUSIC
45

Continued from page 6340

HOW TO TUNE A PIANO

Unisons, Octaves, Laying a Scale. The Piano-tuner's Apprenticeship. Piano-tuning as a Vocation

By ALGERNON ROSE

IN all keyboard instruments tuning is a far more complicated process than it is, for example, in the violin, which has but one string for many notes, and not more than four strings altogether. On the other hand, in the piano, instead of four lengths of catgut, there may be upwards of 200 steel wires strung across an iron or steel framework, the total tension, according to the size of the instrument, being approximately from 15 tons to 30 tons. A tension to so many strings, were every tuning-pin adjusted ever so slightly, would alone demand more time than any professional pianist has to spare.

Unisons. The knowledge most usually required is that for pulling-up and adjusting a new string. First, the broken string must be extracted. To do this in an upright piano (we are not speaking of grands) take off the front. First turn the buttons inside the top panel at the bass and treble ends; draw the front forward, lift it out; turn back the cover or cylinder over the keys and lift it out. If the front and cylinder are joined, both come out together. To remove the action (or hammer mechanism), turn the buttons at either end of it, or undo the thumbscrews. Grasping the hammer rail, draw forward the action. Lift it up out of the sockets and place it on a table, or in some other convenient position. Unfasten the catches under the keyboard. Draw the bottom door forward and take it out. In an upright piano, the gauge for strings varies from treble to bass, from No. 9 to No. 21, the sizes of wire being marked below the tuning-pins. In a trichord cottage, the pins are placed in threes, one over the other. If one string serves for two pins, the bottom pin of one note and the top pin of the next, or the two middle pins of neighbouring notes will need new wire. Having obtained the necessary length (by sending the old wire to a maker as a pattern), bend one end of the steel into a loop ½ in. long. Twist the end round twice, and clip it off with a pair of cutting pliers.

"Chipping Up." Place loop on hitchpin projecting from the iron frame at the opposite side to the tuning-pin. Fit the string between the two pins in the bridge, alternately inside the first and outside the second. Pass the wire up above the keyboard. Thread the string through the hole in the brass stud, if necessary. Cut off the wire with the pliers 2 in. beyond the position of the tuning-pins. Insert the string through the eyehole of the pin. Put the tuning-hammer or tuning-crank on the latter; twist the pin round twice to the right, making the coil even. If the tuning-pin has been taken out of the plank, drive it in with some smart blows from a hammer till even with the other pins. Now turn the hammer round to the right, "chipping up" the tone of the new string with a piece of bone or a mandoline plectrum, until it is in unison, as regards pitch, with the other wires belonging to the same note. After taking off the hammer, replace the action. With the right hand, re-adjust the hammer to the tuning-pin, and with the left try the note on the keyboard. Listen attentively to the throbbing of the vibrations. Gradually turn the hammer to the right until the quick and uneven beats merge into one steady and clear sound.

An identical tone is the easiest for the student to begin with. In trichord pianos, where three strings go to each note, two-thirds of the total are so tuned. When the throbbing has resolved into a steady vibration, the new string will be in unison. To ensure that the note will stand, "set" it by striking the key sharply to ascertain that the wire does not slip through the stud nor over the bridge. If it does, repeat the tuning and the proof till the note holds firm.

Octaves. If a new string put on is a single one of covered wire in the bass (the steel core being overspun with copper), it must be tuned by the octave note above. Strike these two notes together. In point of importance and facility, the tuning of the octave, so far as the student is concerned, comes next to the perfect unison. Though no longer identical, the sounds resemble each other strongly. Turn the hammer on the pin of the new string gradually to the right. Listen attentively. At first the beats will be uneven. When the lower string reaches its proper tension, the two sounds will cease to vibrate unevenly, and the compound tone then produced will blend smoothly. Take care not to raise the new string above the pitch required, or it may break; neither put any side pressure on the tuning-pin, or it may snap off. Avoid turning any pin unnecessarily, otherwise it may become loose, and a piano with loose pins cannot stand in tune.

"Laying" a Scale. In this country tuners generally lay the scale from C (third space, treble clef). On the Continent the start is made from A (second space, treble clef). It is the tuning-fork, therefore, which gives the initial tone. The correct pitch of the latter is thus of paramount importance. Pitch-pipes are not recommended, as they are frequently inaccurate. What is known as "concert pitch" is a nebulous term. In England there is the Kneller Hall sharp military pitch, the low French pitch, and the Society of Arts (or medium) pitch between the two extremes, besides other fanciful standards used by various piano-makers. Accurately measured tuning-forks are difficult to get at an ordinary music-shop. The point is to get a fork at the new pitch (stamped "C 522" double vibrations per second), not the old Philharmonic pitch (C 540), as the latter is considerably sharper, and puts a greater tension on the strings of the piano as it does on the voice of a singer. In addition to a tuning-fork, when tuning a trichord instrument three wedges are needed. These consist of narrow strips of whalebone, or pliable wood, ¼ in. wide and 9 in. long. The ends are padded with one or more layers of wash-leather, the thick tip being for unisons and the thin for octaves. From the front, insert a wedge obliquely through the action, so as not to touch the hammer striking the note to be tuned.

Having wedged out two of the three strings of pitch C, put on the hammer. Sound the tuning-fork by striking one of its blades smartly on the knee with the left hand. Place the small end of the fork on any portion of the woodwork in front of the piano. To the sound it gives C, third space, treble

clef, must now be tuned. Raise or lower the pitch of the string gradually until, when the note C is struck it agrees accurately with the tuning-fork. Stop the vibrations by a wedge inserted between two of the unisons of the C below, and get the octave perfect. Do not strike the lower note too hard at first. The sharp blow is only required for "setting." There are various ways of laying the bearings of a keyboard instrument. Different tuners naturally pin their faith to the methods which they have been taught and have found most useful. But as all these systems, properly carried out, have the same result in making the tone of the instrument agreeable musically, the student may adopt any one of them profitably.

"Tempering" Notes. Presuming that the pupil is musically inclined, it may surprise him to be told that the foundation of the tuning of all our keyboard instruments is intentionally inaccurate. Let him look at the piano for a moment. Enharmonically, every white and every black note has two names, if not three. C natural serves also for B sharp and D double flat; C sharp is also D flat; D natural likewise is C double sharp or E double flat, and so on. Therefore, if we have twelve keys within an octave, we have to make them serve for upwards of twenty-four notes indicated in music. A very clever violinist with a sensitive ear, or a trombone player, because the tone of such instruments is not fixed, will play in what is called "just" intonation. On a pianoforte or church organ, the only intervals *absolutely* perfect with the pitch note are the octaves. The rest of the notes are "tempered." For the purposes of practical harmony, the notes within each octave have been so modified that the acoustical divisions between them have been made as equal as possible.

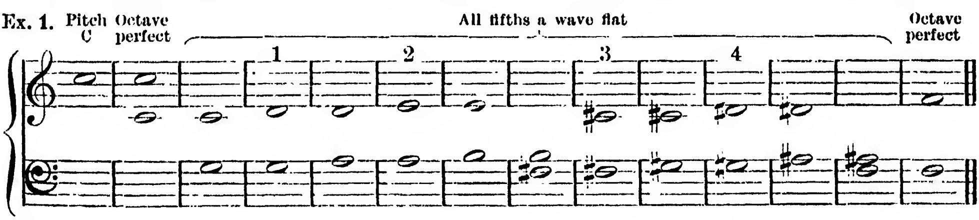
The ear of the musical student may at first rebel against the mutilation of any interval, but the system of modifying the notes within the centre octave internationally adopted is based on common-sense, and has been found the only possible solution of a problem which perplexed musicians for many years. Mathematicians, acousticians, musicians, and manufacturers have written libraries full of books on this subject. It is, therefore, a difficult one to deal with succinctly, and the reader is referred to Example 1.

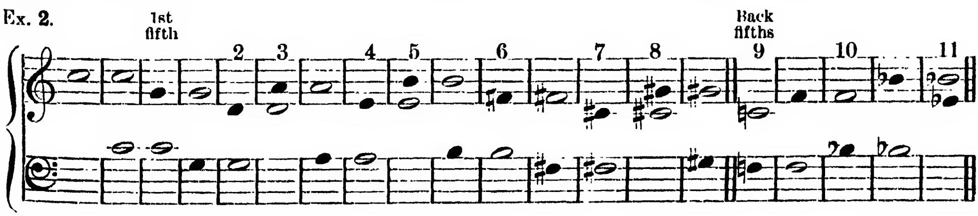
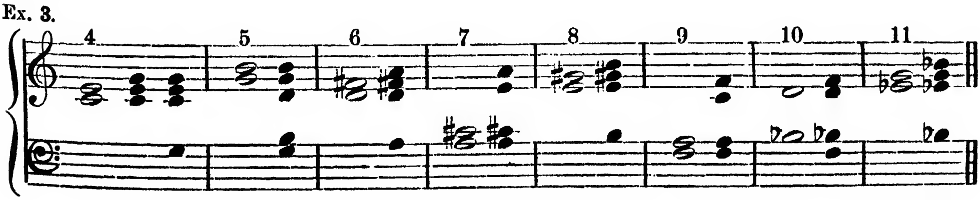
After tuning the octave C, it will be seen that the student must proceed to G below. Tune the fourth perfect. Then from this G get the fifth above, D, "tempering" it by leaving it a beat flat. From the D tune the A below a perfect fourth. Then get the second fifth by tempering the E above a shade flat. Tune the B below a perfect fourth. From the B go down to the F sharp, and make that also a perfect fourth. Now get the third fifth by tuning C sharp a wave flat. Follow with the fourth below G sharp in just intonation, and then, from the G sharp, get the fourth fifth, or D sharp, a shade flat. Proceed to A sharp, a perfect fourth, and then get a fourth below the A sharp, technically E sharp but actually F natural, and, finally, tune the octave F above perfect.

Unless the "shading" has been distributed equally, the octave will not come out perfect, and to proceed any further with the tuning will only magnify the shortcomings of the bearings. Before equal temperament (advocated by the great composer Bach) was adopted, it was disagreeable, on account of the "howlings," to play the piano or organ in the "black keys"—now the most beautiful. As accurate "tempering" is an art which a beginner cannot learn immediately, his first attempt, when proved by the final octave, has, no doubt, revealed that his modifications of the fifths have been overdone. Let him, in going over the work again, therefore, check it in a different manner [Ex. 2].

Here the scheme includes all the keys on the piano between F natural (fourth space bass clef) and C (third space treble clef). But instead of four fifths presenting themselves, the student can check his work by eleven of them. After the low C, tune the G above a little flatter than perfect. Then prove this with the octave G below,

Ex. 1.



Ex. 2.

Ex. 3.

already tuned. From that G, get the second tempered fifth, or D above, and then the third, or A above the D. Now prove this note, which should be a perfect octave with the A below, already tuned. Go over the fourth fifth that now occurs, by checking the E already tuned under the first scheme. Now, get the B above, tempering this fifth fifth a wave flat, and from it prove the octave B below, already tuned.

Next get the sixth fifth, or F sharp above, and from that prove the F sharp below, already tuned. Check again the fifth above low F sharp, with the C sharp tuned according to Ex. **1**. Continue to get the eight fifth, or G sharp above, proving it with the octave note below, already tuned. Having arrived at the eight fifth of the series, the student must return to C. Tune the remaining fifths "backwards," first making the bottom note, F natural, a perfect fifth with the C, and then slightly sharpening it in the same degree that the upper notes were flattened when tuning the other fifths "forwards." By this means, the necessary tempering is done correctly, but the lower note is affected rather than the upper. Then, get the octave F above perfect. Treat the B flat below in the same way, so as to modify the lower note, and keep the upper one just. Get the octave B flat above, and, finally, tune the eleventh fifth, tempering the lower E flat. Of course, as we have first seen, it is not necessary to tune all these fifths in laying a scale, and there are other ways of checking correct equalisation than the scheme last referred to. As soon as the fifth marked "4" in Ex. **2** is reached, the C below gives the major third, and if this third is slightly sharper than perfect, it is an indication that, so far, the tuning is correct. In like manner, test each subsequent fifth by means of the triad [Ex. **3**].

Extending Operations. Upon the bearings laid the rest of the tuning is built up. The unisons, or two other strings, of each first one already tuned must be made to accord (altering the position of the wedge) until each group of three strings blends properly together in sound. This done, proceed to the octaves. Begin on C sharp (first ledger line beneath treble clef) and tune in succession one string of every octave note above until the extreme treble of the keyboard is reached.

All octaves must be "perfect." Then take the E below middle C, and tune each successive note in octaves down to the extreme bass. This done, go over the treble octaves again, as they are apt to fall in pitch as the tension increases on the lower part of the frame. Finally, try together double octaves, to see that all are accurate. Having adjusted all these notes on one string of each group of three, proceed to tune in unison the second and third string of every note. Taking these separately, adjusting the wedges as explained, get all unisons correctly above and below the central octave. To get increased brilliancy and fullness, some tuners pull the high notes a shade sharp, and leave the extreme bass a trifle flat. On completion of the work, clean the keys with a soft cloth slightly moistened with warm water, and replace the front.

Apprenticeship. In every large piano factory labour is much systematised, so that one instrument passes through many hands, each man being a specialist in his own branch. Particular attention is always given to the tuning department, because the best made piano in the world badly tuned will sound at a disadvantage beside one of inferior make finely tuned. But to take off experienced tuners to teach beginners deprives a factory of skilled labour, which has a definite value. Therefore, considering how difficult it is to find remunerative employment for many young men nowadays, the privilege of being taught the art of tuning is gladly paid for by parents when their sons are indentured as apprentices. To acquire the necessary flexibility of finger and perception of wave beats for good tuning, it is essential to begin in early youth when a lad is still growing. When the wrist is once set, it is seldom possible to make what is known as a fine tuner. The usual age for beginning is sixteen. Obtain an introduction to the manager of some well-known factory. If of good physique and character, the candidate's name is put down in the "waiting" list. Notice will be sent when a vacancy occurs. Preference is generally given to the sons of valued employes or good customers. Premiums vary from £5 upwards. Apprenticeship is usually for seven years.

Entering the Factory. The first work is to assist with odd jobs the qualified tuner who acts as instructor, when not employed in "chipping up." By keeping his eyes open, the young apprentice can learn much in a factory in many departments, as his work will not always be in the same shop. "Rough" tuning is generally done in the noisier departments where, in case-making, or marking off, there may be a good deal of hammering, and a subtropical atmosphere. As the lad improves in his work, he will be promoted to quieter regions, giving him an insight into hammer-covering, and ideas as to the latest method of polishing. After a certain length of useful service the beginner will receive a small weekly salary. According to ability to tune, this will rise gradually from 5s. to £1 a week.

When the term of apprenticeship expires, an ambitious young tuner will endeavour to get a few years outside experience. Vacant situations are announced in the various musical papers. Consult the foreman tuner, or factory manager, regarding the status of advertisers before accepting any offer. After an apprentice has done well, the manufacturer will usually be agreeable that he should seek to improve himself practically in some music shop, where he will come into contact with instruments by other makers, and learn to repair harmoniums, American organs, or piano-players in a way seldom possible in any one factory.

Concert Piano Tuning. The laudable ambition of many a young tuner is to do concert work. This, of course, demands the most artistic skill. Having gained outside experience and, subsequently, been received back on the staff of the firm where he was apprenticed, he will find, if the opportunity is given him, that concert tuning entails considerable responsibilities. It involves, during a tour, the constant packing and unpacking of a heavy iron grand, placing it in and removing it from various provincial halls, besides attending each performance after smoothing over the tuning of the instrument. At the concert it is the duty of the tuner to open and shut the piano before and after each solo, and turn over the music in concerted pieces. Yet it brings him into personal contact with some musician of distinction whose good word may be of considerable value. The weekly wage will probably be £2 2s., with an allowance for travelling and hotel expenses. A report should be made on each concert and sent by postcard to headquarters.

PIANO-TUNING *concluded; followed by* MUSICAL INSTRUMENT MAKING

GERMANY AND SCANDINAVIA

The Unification of Germany. Development of Prussia. Progress of Norway and Sweden, Denmark, Turkey, and Greece

Continued from page 6304

By JUSTIN McCARTHY

GERMANY

The Thirty Years War had a very bad effect both on the population and on the commerce of Germany—the population was much diminished, and the commerce destroyed for the time. The country was burdened with taxes, and the empire became divided into a number of small states whose rulers held tyrannical sway over their subjects. Leopold I., who succeeded in 1658, might have done much to restore peace and order in his empire, but he allowed himself to be drawn into a coalition against France. In his reign Strasbourg was added to the dominions of France. In 1705 he died, and was followed by Joseph I. and then by Charles VI., whose successive reigns lasted until 1740. These two kings were the last of the male sovereigns of the House of Hapsburg. During their reigns occurred the War of the Spanish Succession, which was ended by the Treaty of Utrecht.

Maria Theresa. On the death of Charles VI., in 1740, the succession was contested by his daughter, Maria Theresa, and her husband, Francis I. of Lorraine. Maria Theresa claimed the crown by right of the Pragmatic Sanction drawn up by her father in 1713. Charles VII., Elector of Bavaria, was, by the help of Prussia, elected to the Imperial throne in 1742, but was compelled to resign the crown three years later. Francis I. reigned from 1745 to 1765. The Seven Years War, which began in 1756, aggravated the troubles of his reign. His son, Joseph II., succeeded him, but was little more than a nominal ruler during the lifetime of his mother, Maria Theresa. Leopold II. reigned two years and was succeeded by his son, Francis II., who, after the Rheinish Confederation was formed under the protectorate of Napoleon the Great, resigned the German crown, and became Emperor of Austria in 1804.

The Struggle for German States. The history of Germany after the first Napoleon's career began to resolve itself mainly into a rivalry and a struggle between Prussia and Austria for the rulership of all the Germanic states and peoples. Prussia may be described as the rising power, and Austria as the power which had reached its zenith and was already beginning to show signs of decay. The interests of Prussia were entirely Germanic, but Austria exercised imperial sway over nations and states which were foreign to her, and were continually rising in revolt against her rule.

Prussia began to form alliances with the minor states of Germany, and against these alliances Austria issued more than one indignant protest. On January 2nd, 1861, the Prussian king, Frederick William IV., was succeeded by his brother, King William I., whose coronation was celebrated with great pomp at Konigsberg. Before this several attempts had been made to form a Germanic Confederation of which Austria, Prussia and all the minor states should form component parts, but nothing effective or enduring had come of these attempts, most of the smaller states feeling inclined to rank themselves on the side of Prussia, and to be distrustful of Austrian leadership.

Bismarck and Moltke. The Prussian king had as his leading Minister one of the greatest statesmen the modern world has seen—Count Otto von Bismarck, afterwards Prince Bismarck; he also had, as the commander of his armies, one of the greatest soldiers that the modern world has seen—Count von Moltke.

Bismarck was born in 1815. His long struggle with the Vatican, the "Kufturkampf," was a failure. He was known as the "Iron Chancellor" and "The Man of Blood and Iron," the latter phrase taken from a speech of his own.

The struggle between the two rival Powers kept growing, and all attempts to mediate between them or to settle the differences in any satisfactory and lasting form ended in failure. It at last became evident that only war could decide the question. Austria and Prussia had co-operated for the capture of the German Duchies of Schleswig and Holstein from Denmark, but this combined success only led to new disputes between the Powers thus in temporary alliance. On June 15th, 1866, Prussia declared war against Austria, and on July 3rd, 1866, was fought the great battle of Sadowa, which may be said to have marked the close of the contest, a contest in which Austria had suffered nothing but losses, resulting in her absolute exclusion from Germany.

Prussia's Development. One immediate effect of Prussia's victories was to create in her a military power which seemed seriously to threaten the domination of the French Empire under Napoleon III., and in consequence, on July 15th, 1870, Louis Napoleon, acting, it is believed under the advice of unwise counsellors and contrary to his own personal inclinations, declared war against Prussia. The result of this policy was the complete overthrow of the French armies in that memorable struggle, which, when the French had suffered defeat after defeat, and the crowning defeat at Sedan, ended in the capture of Paris itself on January 28th, 1871, and the proclamation at Versailles of King William as German Emperor. From that time the Kingdom of Prussia has lived as the German Empire, including under its sway, or as its allies and fellow-workers, most of the other Germanic

states, Austria being entirely excluded from cohesion with Germany. Since that time Prussia has engaged in no war, and, although she has had to undergo many grave political and religious struggles within her own sphere, she has been occupied only with the interests of the German Empire. William I. died on March 9th, 1888, and was succeeded by his son, Frederick III., who died June 15th, 1888, and was followed by the present Emperor, William II.

NORWAY AND SWEDEN

As Charles XII. of Norway left no heir, the crown went to his sister Ulrica and her consort, Frederick of Hesse, who was crowned in 1720. Next came Adolphus Frederick, who reigned until 1770. In his reign the nobles were divided into two parties—the "Caps," who were the peace party, and the "Hats," the war party.

Gustavus came to the throne in 1771, and abolished the Council of State and restored the Constitution. He was assassinated, and his successor, Gustavus IV., was dethroned, and during some of the wonderful changes caused in Europe by the career of Napoleon, Bernadotte, one of his generals, was elected to the throne of Sweden as Charles XIV. He had to resist the efforts of his old commander, Napoleon, to obtain complete power over Sweden, and he won for himself the character of a sagacious ruler animated by the best intentions for the good of the country over which he had so unexpectedly come to reign. Sweden joined the Grand Alliance against Napoleon in 1813.

It is not necessary to give a list of the sovereigns who governed Sweden and Norway under the new constitutional arrangements; the kingdoms were prosperous and for the most part peaceful. There were many Arctic expeditions, and many institutions were formed for the preservation of Sweden's older literature and for the promotion of culture. These systems were successful in causing the spread of popular education. Continual difficulties and troubles arose, however, from the efforts of the Norwegians to obtain a satisfactory constitution of their own, and these ended at last in a friendly separation which gave to Norway a separate government and even a separate king, while the two kingdoms still remained in friendly and peaceful association.

Separation of the Kingdoms. On June 7th, 1905, the Norwegian Parliament decided on a final separation from Sweden. It was felt that this resolve of the Parliament should be submitted to a popular vote, so on August 13th the voters endorsed the resolve by a plebiscite, giving a majority of 368,208 for the separation against only 184 votes for the retention of the existing union. On September 23rd the Swedish and Norwegian delegates met in conference and agreed to the terms of the separation. Amongst the conditions were a neutral zone on both sides of the southern border between the two kingdoms, and the dismantling of certain fortresses. On November 18th Prince Charles of Denmark was elected King of Norway, and assumed the title of Haakon II.

DENMARK

The later history of Denmark tells of many struggles and yet of much substantial progress. In 1665 the sovereign was made absolute and hereditary, and early in the following century Frederick IV. added to his dominions the Duchies of Holstein and Schleswig. Denmark became engaged in war with England during the convulsive period following the French Revolution, and its capital, Copenhagen, was bombarded by Lord Nelson in 1801 and by Admiral Gambier and Lord Cathcart in 1807, when the whole Danish fleet was compelled to surrender. Frederick VII., who succeeded in 1848, proclaimed a new constitution, by virtue of which he endeavoured to unite Schleswig and Holstein more closely with Denmark, and thus to absorb or extinguish their nationality. The immediate result was an insurrection in the Duchies and the formation of a provisional government. The forces of the Duchies were defeated, although the Prussians lent them some assistance. The European Powers recommended the making of peace, but hostilities went on, with success now on this side and now on that, but with nothing decisive either way. A new and somewhat liberal constitution for Denmark was sanctioned by the King and Parliament in 1849, and peace was made in 1850. On March 10th, 1863, the Princess Alexandra of Denmark was married to the Prince of Wales, the present King of England.

The Fate of Schleswig-Holstein. The Schleswig-Holstein question was now coming to a crisis. Schleswig, Holstein, and Lauenberg were entirely German in their populations, and were held by the King of Denmark as Duke of Lauenberg in the old Germanic Federation, while Schleswig was more directly attached to the Danish Sovereignty, though there was a large German population, especially in the Southern districts. The whole German people were concerned in the question, and could not endure that their countrymen should be under the rule of a Danish sovereign. Frederick VII. of Denmark had no direct heir, so the succession had already been arranged by the great European Powers by the Treaty of London in 1852, which declared Prince Christian of Schleswig-Holstein heir to the crown, with the title of King Christian IX. His claim, however, was disputed on the death of King Frederick VII. in 1863, by the Duke of Augustenburg, who took the title of Duke Frederick VIII. of Schleswig-Holstein. Count Bismarck, who was then the ruling statesman in Prussia, determined that the Duchies should be annexed to Prussia, and the dispute about the succession gave him his opportunity.

The War with Austria and Prussia. The Germanic Federation entrusted the conduct of the dispute to the combined powers of Austria and Prussia, and the Danish Government had a strong hope that England would come to their aid. Lord John Russell, then Prime Minister, had often told the Danish Government that they must, if only for their own interests, deal justly with their German subjects. He

had never sanctioned the policy which strove to bring the Germanic peoples into absolute subjection to Denmark, and he had made it clear that if Denmark did not take England's advice, England would not come to her aid in the event of war. In the war which ensued Denmark had to fight against Austria and Prussia. The Danes fought bravely, but they were utterly outnumbered, and their old-fashioned weapons were of little use against the needle-gun, the new weapon of their opponents. The Danes gained one victory over some Austrian warships in the German Ocean, but they lost all their fortresses, and their defeat soon became certain, even to themselves. Denmark, after some futile negotiations, had to accept terms of peace and to give up the Duchies to Austria and Prussia. By the Peace of Vienna in 1864 the King of Denmark resigned the Duchies to the Allies, consented to a rectification of his frontier, and agreed to pay a large sum of money towards the cost of the war.

The remainder of Denmark's history has few international interests. The Danes are a people of great intelligence and culture, and have given many famous names to literature, the arts, and sciences, among whom we can only mention Hans Christian Andersen, the famous writer, and Thorwaldsen, the great sculptor.

TURKEY

The advance of the Mongols to Khorasan drove the inhabitants, called the clan of the Oghuz, to Armenia, where they helped the ruler to repel the Mongol invasion, and, in return, he gave them land in Asia Minor near the Province of Bithynia. The Ottoman Empire began in Sugut, the city where their leader settled in the thirteenth century. Ertughrul—this was the name of the leader—has been followed by thirty-five descendants, Sultans of the Ottoman Empire. Sugut was the birthplace of Osman, from whom comes the name Osmanlis, now generally called in Europe, Ottoman. Osman and his son added much territory by conquest to their dominions.

In the time of peace which followed some of these wars of conquest, the Ottoman ruler organised the state and formed a standing army—the first, it is said, in modern history—the corps called the Janizaries, which became so powerful later on as to be an important element in the state. Murad I., the first "Amurath," who came to the throne in 1359, added Adrianople and Philippopolis to the dominions of Turkey, and in 1364 defeated the Servians and the Hungarians. He had many wars with the Christians, who tried in vain to resist him. In 1389, the Turks won a great victory, in the Battle of Kosovo, over a large army led by Lazerus the Servian, but Murad I. was assassinated in the same year.

The next important event in the history of the Ottoman Power was the invasion of the famous Tamerlane, which stayed for a time the wave of Ottoman success. The Tartars defeated the Turks, and took the Sultan prisoner in 1402, and the conquering days of the Ottomans seemed to have come to an end, but, under Mohammed I., called "the Restorer," its greatness revived. He transferred the capital of his country from Asia to Adrianople in Europe. In the reign of Murad II., the great Hungarian General, Hunyady, known as the "White Knight of Wallachia," was the most formidable opponent of the Turks; he defeated them in two battles, in 1442 and 1443, and compelled them to make a treaty of peace for ten years, to free Servia, and to cede Wallachia to Hungary. Notwithstanding the treaty, Hunyady invaded Turkey soon after, but the Christians were defeated by the Turks at Varna in 1444, and the King of Poland was killed.

The Siege of Constantinople. Mohammed "the Conqueror" reigned for thirty years, and in his reign occurred the siege and capture of Constantinople, one of the most important events in Turkish history. This was in 1453. Another event was the defence of Belgrade, three years later, by Hunyady and John Capistran. The Ottoman Power annexed Greece and most of the Isles of Greece, and also the Crimea in 1475, and Otranto in Italy in 1480. In 1481, Mohammed died whilst about to start on fresh conquests, and was succeeded by his son, whose reign was uneventful. With Selim I. began another epoch of Turkish conquests; he defeated the Shah of Persia in a great battle, and captured much of his territory. He also annexed Syria, and took Egypt from the Mameluks in 1517. But the reign of his son, Suliman, "the Magnificent," is perhaps the greatest epoch in Turkish history. In the forty-six years of his rule he conquered Belgrade and the Island of Rhodes. He defeated the Hungarians in a great battle, in which their king and most of his army were killed, and made Hungary part of the Ottoman dominions for 150 years. He also laid siege to Vienna, but was unsuccessful, and in 1533 made a truce with the Emperor, Charles V.

Battle of Lepanto. Suliman died in 1566. The next reign saw the famous Battle of Lepanto, in 1571, and also the first war between the Turks and the Russians, in which the Turks were unsuccessful.

It is not necessary to give a list of all the Ottoman sovereigns who followed; their reigns saw many wars with Persia, with Austria, with the Venetians, and with other European powers, in which Turkey was sometimes victorious. But her greatest days were over. In 1686, the Turks, undeterred by previous failure, again laid siege to Vienna, and were utterly defeated by Duke Charles of Lorraine and John Sobieski, the King of Poland. The Austrians afterwards took Hungary. Ahmed III., who succeeded in 1703, was the Sultan who refused to hand over Charles XII. of Sweden to the Russians after the Battle of Poltowa, in consequence of which Peter the Great invaded Moldavia; but he was so unsuccessful that he would have become a prisoner of the Turks but for the intervention of his Queen, afterwards Catherine I.

Later on in the century, however, Russia began to be successful in her wars with Turkey, and after many wars, in which the

Russians were generally victorious, the Treaty of Kuchuk Kainarji was made in 1774. But notwithstanding this treaty, the Russians, nine years later, took possession of the Crimea and the country to the east as far as the Caspian Sea. The wars continued through some years of the reign of Selim III., but occurrences in Western Europe soon made the Russians wish to end the war, and a treaty of peace between the two countries was signed at Yassy in January, 1792, which confirmed the former treaty of Kainarji. By the peace which was now secured the Sultan was able to turn his attention to reforms in his own dominions. But, like many reformers who are in advance of the popular opinions of their time, his projected improvements were too much for his subjects, and brought about his dethronement and his death. After the short reign of his successor, Mahmud II. came to the throne, and in his reign occurred the War of Greek Independence. At that epoch began again the history of Greece, of which there is nothing to relate from the time when she came under the dominion of the Ottoman power until she regained her freedom in the year 1821—a year made for ever famous by that event.

GREECE

Greece had for many centuries ceased to be known as a distinct nationality. During the later of these centuries she was entirely under the barbaric rule of the Turks. Yet throughout that long period of subjection, and of what often seemed to be utter national extinction, the Greeks never became absorbed into the dominion, the kinship, or the ambitions of the ruling race. The Greek, when he had to make a living, took service wherever he could get it, but he still remained a Greek. The Turks had made themselves odious to the civilised world, and early in the last century it became evident that Greece would take advantage of Turkey's troubles with foreign states to strive for her national independence.

The Greek War of Independence. In March, 1821, Prince Alexander uplifted the national standard, and soon after that the War of Independence actually began. The Greeks won many victories, and captured the famous town of Missolonghi in November, 1821, after a long siege. On January 27th, 1822, their independence was proclaimed. The Greeks also won a great victory on July 13th, 1823, at Thermopylæ, a fitting scene indeed for the patriotism and the warlike genius of Greece once again to assert themselves. Lord Byron arrived in Greece in the August following, devoting his life to the cause of her freedom. He died of fever, however, not very long after, at Missolonghi. On October 12th, 1824, Greece set up her Provisional Government. The Turks meanwhile won several victories, chiefly under the leadership of Ibrahim Pasha, who for a time recaptured Missolonghi. One of the most brilliant of the Greek soldier patriots was Marcos Bozaris, who won several victories for the Greeks, and died on the field in an attack on the Turkish army.

Intervention of the Powers. The sympathy of Europe was almost universally with Greece, and a treaty was signed at London on July 6th, 1827, between Great Britain, France, and Russia for the defence of Greece. The result of this united movement was the complete defeat of the Turks, and by the Treaty of Adrianople, signed on September 14th, 1829, the Ottoman power acknowledged the independence of Greece. Greece became a kingdom under the protection of Great Britain, France, and Russia.

The crown of the new kingdom was offered to Prince Leopold of Saxe-Coburg, but was refused by him on the ground that the boundaries of the new kingdom did not include the whole Greek nationality, and especially excluded the Island of Crete. The crown was then offered to, and accepted by, King Otto of Bavaria, who was made King by a Convention signed May 7th, 1832, and he assumed government on June 1st, 1833. He proved a despotic ruler, and had to leave Greece in 1861, and a son of the King of Denmark was made King with the title of King George I. The new king was born in 1845, and at the time of his becoming king the Ionian Islands were restored to Greece. King George I. was unpopular for a time because of his unwillingness to go to war with Turkey, which the Greeks, as a whole, wished to do. But during his reign the condition of Greece was prosperous, notwithstanding political and financial troubles, until the time of the disastrous war with Turkey in 1896.

The Greece of the Present Day. The constitution of Greece places the executive power in the hands of the King and his Ministers, and entrusts the legislative power to a single representative chamber elected by manhood suffrage for a period of four years. Greece has since been on the whole a prosperous and progressive country, although the fact that so much of Greek soil and so many Greek populations were still cut off from her became the occasion of many struggles against Turkey. The Island of Crete was by the protecting Powers released from the baneful control of Turkish rule and placed under the control of a High Commissioner, at present Prince George of Greece, assisted by his councillors and a representative assembly. There is a strong demand among the Greeks of the Kingdom and of the island alike that Crete shall be allowed to became an integral part of the kingdom, and there cannot be much doubt that this national demand will before long have to receive complete satisfaction. Greece is a country in which education is widely spread. The intelligence of the people displays itself in agriculture, in trade and commerce, in literature, in arts, and in political life.

Continued

SAW DETAILS

Varieties of Saw Teeth. Drunken Saws. Tension of Saws. Saw Guards. Planing, Jointing, and Thicknessing Machines

Continued from page 6360

By FRED HORNER

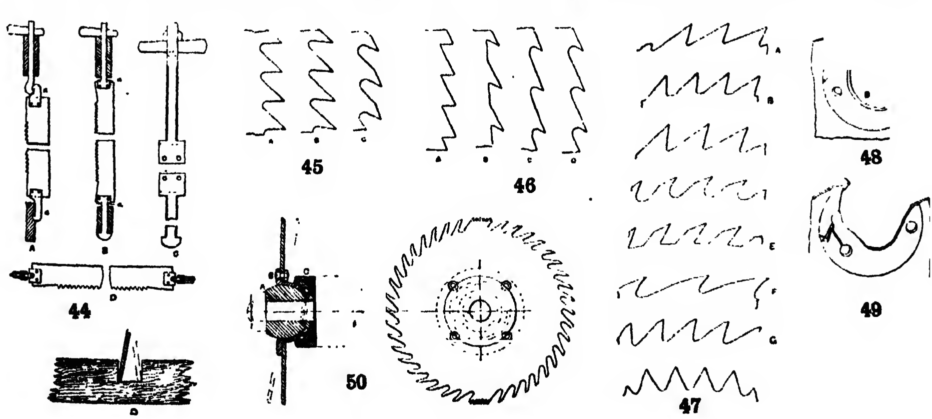
DEVOTING now a brief space to the consideration of the saws which are used in the various machines hitherto described, we begin with the frame-saws. The types employed in the log and deal frames [**44**, A and B] are long flat blades, or *webs*, to which are riveted *buckles* [*a*] held at the bottom end of the swing frame by a hooked portion, or by a head, and strained up in the top by *tillers* and cotters. Enlarged views of the buckles and cotter are given in C. The horizontal board-cutting machines have saws like D, attached and strained with buckles and screws tightened up with nuts.

The shapes of the teeth for such saws are shown in **45**, A and B being triangular, with a moderate amount of radius at the roots, C, with a *gullet* tooth, while the horizontal machines use webs with double sets of teeth, placed in reverse fashion, D, to cut in both directions alternately.

Band-saws. Band-saws are necessarily very flexible, to lap around the pulleys, and endure the constant bendings and straightenings which go on, and the temper must be uniform throughout the blade, in order to avoid cracks and breakages. The sizes range from ⅛ in. to 16 in. wide. The most common shape of tooth is that at A in **46**, while other shapes are shown at B, C, and D, with a greater amount of radius at the roots. The pitch or distance apart of the tooth-points is greatly varied, according to the size of the saw and the class of work which it has to do. Thus an ⅛-in. blade will have nine teeth to the inch, ¼-in. six, 1-in. three, and so on. The blades are made in lengths from which bands of suitable size are prepared, by brazing the ends together. A *scarf* joint is formed by filing down each end for a little distance, so that when the ends are lapped over each other the combined thickness is equal to that of the rest of the blade. Brass or silver solder is used, in the form of sheet, wire, or filings. The silver solder has the advantage of melting at a lower temperature than brass, although its cost is greater. After scarfing, the ends of the saw are placed in special screw clamps, which retain the blade in correct position, with the back in line. Powdered borax paste is applied to the joint, and the solder put in place. On the application of heat the solder fuses, and the joint being pressed together, a union results. Iron wire is usually bound round the ends to keep them together until set. The method of applying heat varies. Sometimes a special pair of thick tongs is made hot and pressed over the joint, or an oil-flame is used in conjunction with a blowpipe. There are also brazing machines, constructed with a hearth beneath the clamps, so that a charcoal fire can be lit to play around the joint. The superfluous solder is subsequently cleaned off with a file, to make the blade thickness uniform.

Tension of a Band-saw. The *tension* of a band-saw blade relates to a certain slackness of the centre, produced by a hammer, or by rolls, the effect of which is to cause the blade to bear on the pulleys with its outer edges, and not in the middle plane. The tension is produced by working about the central plane, or reduced by working along near the edges. The amount of tension varies for different saws, and the makers provide tension gauges, of certain set curvatures, by which to test the tension. Twists and lumps in the blade are tested by applying a short straightedge, while the saw lies on a levelling-table, and are eradicated by light blows with hammers.

Another point is that, to run properly, the back of the saw must be perfectly straight. A long straightedge is applied to test the accuracy or otherwise, and the matter put right by hammering or by rolling. Should the back be concave, the surface is worked over near the back with a series of blows extending to the central portion; if convex, the



SAW TEETH

44. Frame saws **45.** Frame-saw teeth **46.** Band-saw teeth **47.** Circular-saw teeth **48** and **49.** Inserted chisel-point teeth **50.** Drunken saw

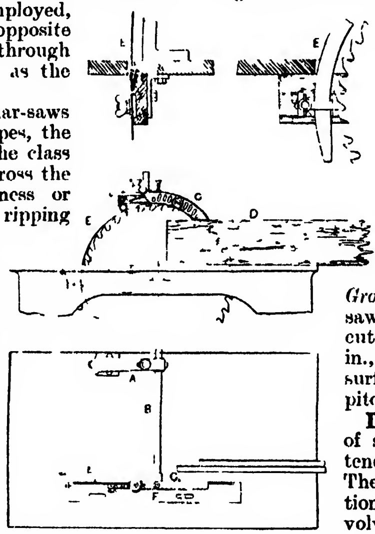
hammering must be done near the toothed edge. The necessary side clearance of a band-saw blade in the timber is obtained either by forcibly setting over each tooth alternately to right and left, so that the resulting cut is wider than the blade itself, this being termed *spring set*, or by *swaging* the points of the teeth—that is, applying pressure to the front of the teeth, so spreading them sufficiently to clear the blade in the cut. This is the *swage set*. The latter is not quite so smooth cutting as the spring set, but operates quickly. Swaging is effected by an appliance fitting over the blade and forcing hardened dies against the tooth faces. Spring setting is performed by side pressure, or by blows, which force the teeth over to an exactly uniform extent all along. The simplest sets comprise a block and a punch, which is struck with a hammer, to drive the teeth into a recess in the block. Other hand sets are constructed something like pliers, with an anvil, against which the teeth are forced by a plunger, brought into action by squeezing the handles of the tool together. Where a sufficient run of work is certain, a machine of automatic character is employed, having steel hammers on opposite sides of the saw, which is fed through by a ratchet or other device as the teeth are set.

Circular Saws. Circular-saws have teeth of very diverse types, the shapes of which depend upon the class of cutting, whether with or across the grain, and the relative hardness or softness of the timber. For ripping soft woods, the teeth are spaced widely, and are formed more acutely than for the harder varieties. Figure **47** illustrates some of the commoner shapes of circular-saw teeth in use. A, B and C are triangular teeth, with more or less rake, for softer woods; D has gulleted teeth, which afford great freedom for the sawdust. Two other shapes for ripping are shown at E and F. G is for ripping hard wood, the rake being lessened accordingly. Cross-cutting requires a different form of teeth, because, instead of passing down and forcing the fibres asunder, as with ripping, the saw has to sever the fibres at right angles, which imposes much more resistance. The shape of tooth is that of an equilateral triangle, called a *peg* tooth, H, and it is bevelled to produce a keen edge, each tooth having the bevel facing in an opposite direction to that of the adjacent tooth. There is no hard and fast rule for the use of the peg-tooth, since some of the other previous shapes of teeth, notably D, are used freely for cross-cutting in the soft woods, but they are limited to these woods.

Inserted Teeth. The Americans have developed a class of circular-saws with *inserted* teeth, which are used largely for diameters above about twelve inches. The advantages claimed are that a better class of tooth can be produced, as regards temper and clearance, than when the teeth are formed out of the solid plate, and also that in the event of nails or spikes being encountered in the timber, the damage to the saw is far less, because at the worst a few teeth are broken off or torn out without damaging the plate, and can be quickly replaced with new ones. But a solid-tooth saw under the same circumstances may have several teeth broken out, necessitating the reduction of the entire diameter to bring it down sufficiently to make a new set of teeth all around. The fitting in of the tooth is effected by vee edges, which prevent lateral movement, and the actual cutting portion or *bit* [A, **48**] is secured by a *shank*, B, the two wedging together firmly when slipped into place by the help of a special wrench, having a pin fitting in the hole in B. The shank is split in some cases to produce a decided spring, to retain the parts in place [**49**].

Special Saws. *Ground-off*, or *bevelled*, or *swaged* saws are tapered off in thickness from the centre to the edge, which may be very thin, while still leaving the body stiff. The grinding-off is done only on one side. The result of thinning the saw thus is to save wood in the kerf, and to enable fine sawing to be done, so that these ground-offs are very suitable for fine cabinet and box-work. The teeth of swaged saws are pitched rather closely together, and are smaller than those of ordinary, or *plate* circular saws.

Hollow-ground saws are a class which work without set, the clearance being provided by grinding each face tapering from the teeth to near the centre, where a parallel portion is left for the spindle collars to grip. As the teeth are wider than the blade behind them, there is no side friction. These saws make a very smooth cut, and are used for the finer classes of work, including mitre cutting. *Grooving* saws are hollow-ground saws, made of definite thicknesses to cut grooves, ranging from ⅛ in. to 1 in., or more. They leave a very smooth surface. The teeth are coarsely pitched for good clearance.

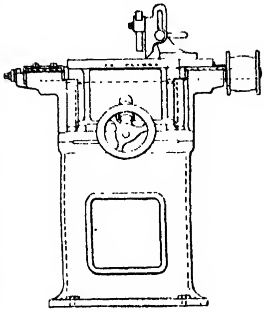


51. CIRCULAR SAW GUARD

Drunken Saws. Another class of saw employed to cut grooves or tenons is the *drunken* or *wobble* saw. The blade is held in an oblique position, so that it wobbles while revolving, or alternately travels from one side to another, so that when fed into the wood a slot is cut out. Bevelled washers are employed in some fittings to cant the saw. Figure **50** illustrates a saw by Carron Company, Carron, Stirlingshire, which has a ball centre, A, upon which the saw, bolted to a socket, B, embracing the ball, may be moved to give any required inclination within its range. B has a stud fitting in an inclined groove cut inside in the surface of a washer, C. The whole arrangement is firmly clamped by the nut, shown dotted, at the end of the spindle, and the saw cannot alter its angle until this nut is slackened. The saw-blade, shown in place, is a type much used for grooving, differing from ordinary ones in having a couple of sets of *cleaning* teeth which ensure a smooth surface. The diagram at D shows the action of the drunken blade in a groove. The saws are usually made in a range of sizes from 7 in. to 16 in. diameter, cutting slots of from ⅛ in. to 1¼ in., and from $\frac{3}{16}$ in. to 4 in. respectively. By putting oval or elliptical blades on, round bottomed grooves may be cut.

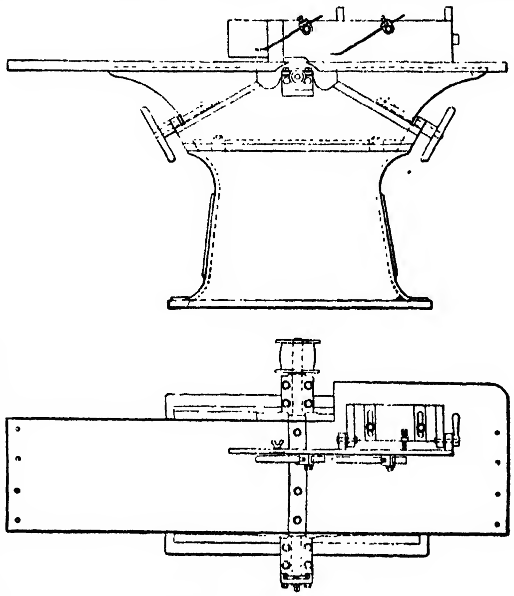
A few other special saws may be mentioned, such as the *segmental* types, which have their blades

built up of radial segments mounted on a central boss, by which device a thinner edge can be obtained than by using a solid plate. These are used for thin re-sawing work, and for veneers. *Concave* saws are dished to form the envelope of a sphere, and are employed in cutting curved pieces, such as for wheel felloes and barrel parts. *Cylinder* saws, which are in the form of a large tube, with teeth on one end, saw out barrel staves to the correct curvature on one side.



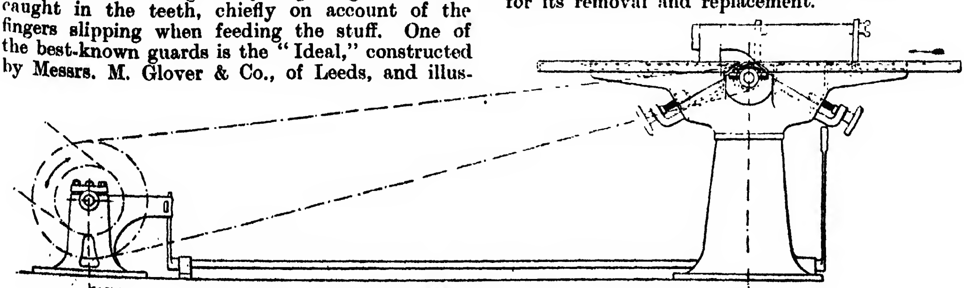
Tension and Packing. The *hammering* of a circular saw is done to bring it into a proper condition for true running; there may be tightness or *tension* at the rim, or near the centre, according to the manner in which the hammering is done. The apparent rigidity of a saw plate disappears as it attains a high speed, and it becomes limp and pliable and is very susceptible to lateral pressure. There is a certain critical speed for every saw, at which it will run true, if hammered accordingly, but if the speed is altered, or the saw becomes reduced in diameter through repeated sharpenings, in the course of time, re-hammering is required. Another feature of great importance is the *packing*, which usually consists of hemp, plaited, and packed in on each side of the plate, being supported by boxes or strips underneath the table. The object is to support the saw laterally and enable it to stand up to the work without running out of truth, which it would do on encountering variations in the timber. There is another effect, that of imparting a certain amount of warmth to the saw plate, regulating the tension, and preventing buckling. The running of the saw can be controlled by packing harder or softer. Thus a saw that is "loose" on the rim may be made to run properly by packing rather tighter near the centre than towards the periphery, so that the central area is warmed up, and so the metal expands more, pressing on the rim portion, and checking the unsteadiness. The packing is lubricated by some class of rather thin oil.

Saw Guards. The question of a provision of a *guard* to a circular saw has to be considered; it is a very dangerous tool, and many accidents have occurred through sawyers getting their hands caught in the teeth, chiefly on account of the fingers slipping when feeding the stuff. One of the best-known guards is the "Ideal," constructed by Messrs. M. Glover & Co., of Leeds, and illustrated in **51**. It is so made that the saw is completely protected, no matter what the height of the wood being sawn. The device comprises a bracket, A, bolted at the back of the saw-bench, and supporting a steel shaft, B, centrally above the saw spindle, by means of another vertical shaft, in order that the guard may be altered to suit differing



52. HAND PLANER

diameters of saws. The actual guard or hood, C, cast in brass, and perforated to let the sawyer see the line of teeth, is hinged, so that it falls automatically down on to the timber, D, and leaves no portion of the teeth exposed. The rear portion of the saw is guarded by a *back knife*, E, slightly thinner than the saw, and attached by a sliding clamp beneath the bench [see the enlarged detail], and above to the hood-holder. This back, or *riving* knife prevents the sawyer from getting his fingers into contact with the teeth, and also obviates the danger of stray pieces of wood touching the back, and being thrown up by the teeth with great force into his face. E is the loose *finger-plate* (not previously referred to) with which saw-benches are provided, to enable the saw to be removed, and to the underside of which one of the packing-strips is attached. A couple of slots in the finger-plate enable the operators' fingers to be inserted for its removal and replacement.



53. HAND PLANER, SHOWING COUNTERSHAFT DRIVE

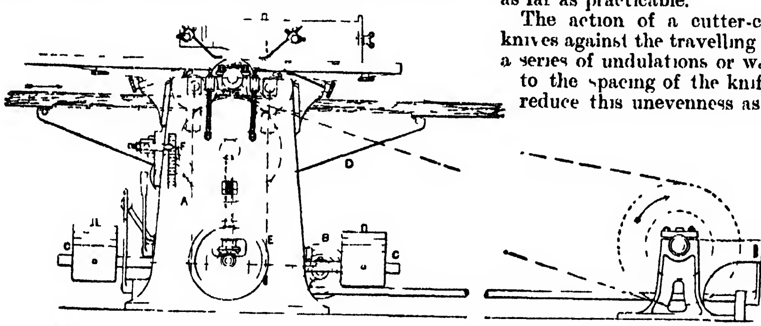
Planing Machines. The *planing* machines constitute a large group, which operate by *cutters* or *knives*, either revolving or fixed. They true up narrow or broad surfaces, cutting on one or on several sides of the timber, and have hand or power feeds. The simplest class of planer is that represented in **52** (Messrs. John Sutcliffe & Son, Ltd., Halifax), termed a *hand* or *overhand*, or in America a *buzz*-planer. The frame carries bearings for a revolving spindle, which holds two or three long cutters revolving at a high speed, the spindle being driven from the belt pulley at one end. The timber is passed over the two tables projecting out at each end, and adjustable vertically upon sloping ways by screws and hand wheels. The fence on the right-hand table guides the wood in a straight line, and can be canted over for angular work. The two curved springs passing down the front keep the timber upon the table. In operation, the right-hand table is set lower than the left-hand one by the amount necessary for the cut, and the workman, standing alongside this right hand table, passes the wood over it and the cutter spindle until the other table receives it. The machine is often termed a *jointer*, because one of its principal functions is that of preparing edges for gluing together. Planing out-of-wind, surfacing, chamfering, rebating, etc., can be done also, or by putting in special cutter-blocks, mouldings and tongues and grooves can be produced. The machine shown will plane to width of 16 in., the spindle makes 800 revolutions a minute, and about 3 B.H.P. is required for driving.

The illustration [**53**], showing a similar class of hand planer and jointer, by Messrs. John McDowall & Sons, Johnstone, includes also the driving arrangements. A countershaft is placed on the floor, and carries one pulley which is driven from the line shaft and another belted to the planer-pulley. The belt is shifted from the one fixed pulley on the countershaft to another loose one adjacent, the striking gear being connected by a long rod to a handle at the end of the planer, so that the operator has complete control without moving away. The tables in both of these machines are fitted with adjustable upper slides, which can be drawn back sufficiently to allow of extra overhang of grooving or other cutters.

These planers are sometimes adapted to the requirements of wheelwrights by fitting curved guides at the front, to pass felloes over an extension of the cutter-block, and so to plane the inside to a regular curve. A boring and mortising attachment is also included when desired; it is fitted similarly to that mentioned previously in connection with circular-saw benches.

The hand planer is one of the most dangerous machines to operate, because the knives revolve between the lips of the tables, and the attendant's fingers are very liable to slip into the opening and become mangled. The safest class of work is that of shooting the edges of boards, in which case the hands are raised up to a considerable height from the knives. A safety guard, as applied to such planers, comprises a bridge spanning over the opening, its height being variable to suit the thickness of wood being planed, so that there is no chance of the workman's hands touching the cutters. If thin boards, etc., are being surfaced, the guard reaches across to the fence; but if edges are being planed, the guard is drawn away from the fence sufficiently to let the stuff pass, leaving the rest of the gap covered. The opening between the tables is made as narrow as possible in most machines by screwing thin tapered steel lips on to the table edges, projecting over the cutter-block as far as practicable.

The action of a cutter-cylinder, revolving the knives against the travelling wood, tends to produce a series of undulations or waves, which correspond to the spacing of the knife strokes. In order to reduce this unevenness as much as possible, the diameter of the cutting circle must be small, and the speed of rotation high, while steadiness of running is essential also. The last-named feature can only be secured by accurate balancing of the cutters and well-fitting bearings. The latter are made very long, and have adjustments for taking up wear.



54. 15 IN. × 7½ IN. SURFACE PLANING AND THICKNESSING MACHINE

Surfacing and Thicknessing Machine. An advance on these machines is the combined surface planer and *thicknessing* machine [**54**], which has a power-feed by rollers, passing the timber through between the rollers and the cutters, and reducing it to an even thickness. One side of the stuff is previously trued upon the surfacer. The upper portion of the machine in **54** (also by Messrs. McDowall) is formed like the preceding one; the arrangements for thicknessing include four serrated rollers, lying to right and left of the spindle, and passing the stuff between them, the upper rollers being positively driven by spur gears (the dotted circles of which are indicated), deriving various rates of speed from cone pulleys at A and B. Heavy adjustable weights at CC press upon levers which pull down the top rollers and enable them to get a bite on the wood. The table, D, supporting the latter, is raised or lowered by a vertical screw, operated by the hand wheel, E, and an index scale at F shows the thickness being planed. The arrows show the directions in which hand and power feed are given, these necessarily being in opposite directions, on account of working above and below the cutter-block respectively.

Continued

WELDING AND SOLDERING

Continued from page 6314

Welding Various Metals. Autogenous Welding. Air-hydrogen, Oxy-hydrogen, and Oxy-acetylene Blowpipes. The Use of Thermit. Hard and Soft Solders

In the manipulation of metals it is essential that there should be simple and efficient methods of uniting two pieces of the same or different metals, and there are many processes for making such unions. The ideal method is by *welding*—that is, by fusing, or almost fusing, the edges of the metals to be united, usually by the heat of a coke fire, and by hammering the edges until the opposing surfaces become merged into each other, making a homogeneous and strong union. In making a weld—with two pieces of wrought iron, for instance—the finished work may be as strong as if it had originally been rolled in one piece; and if a subsequent rupture takes place, it is as likely to be at some other spot as at the weld. But many metals—such as cast iron, many steels, zinc, brass, etc.—cannot be welded by the simple process described, and some cannot be welded at all. In cases where the temperature of the coal or coke fire cannot raise the metal to a temperature sufficiently high to permit welding by the time-honoured method of heating in the fire or blowpipe, the process of electric welding may be employed, and is extensively employed in welding steel. The air-hydrogen blowpipe—that is, a blowpipe the gas of whose flame is a mixture of air and hydrogen—is also used in the process known as "burning" or autogenous soldering or welding. Now the oxy-hydrogen and the oxy-acetylene blowpipes are employed for the same purpose. The wonderful *thermit* process introduced a few years ago is also of great industrial importance, and by its agency welds in difficult positions are easily and economically made. It takes advantage of the great affinity of aluminium in the form of powder for oxygen and the very high temperature attained during the process of chemical union. All these processes we shall consider at some length.

Soldering. But in addition to the various welding processes there are the processes of soldering, which may be divided into two classes—hard soldering and soft soldering. The value of soft soldering compared with welding is that it may be used without necessarily spoiling the appearance of the surfaces being united. In soldering, the two surfaces to be joined are not raised to the point of fusion. Union is attained by the use of a third substance—the *solder*—an alloy with a lower melting point than the metal being joined, which, by the help of a *flux*, is made to flow over the surfaces to be placed into contact, so effecting union. Soft soldering does not give such an intimate union as welding, but it is sufficiently strong for very many purposes. Ordinary tinware is invariably soft soldered. The process is the only one that would permit the tin-coated iron surface to retain its finished appearance.

Hard soldering, on the other hand, uses alloys of a much higher melting point than the soft solders, and the unions are therefore stronger. These hard solders are usually termed in the trade "spelter" or "brazing spelter." The name should not be confounded with the word "spelter" used as a synonym for ingot zinc.

We do not include in the processes of uniting metals the mechanical one of riveting, which scarcely falls into the classes of work we set out to consider.

Welding. Welding is possible with those metals which, as they are raised under the influence of heat from cold to the fused or molten state, pass through a pasty or plastic stage. This plastic stage is the welding heat. The ends of two bars of iron may be heated to this welding heat, placed in contact and hammered, and the result is a weld. The ends may be sloped or upset; or one may be split and the other pointed, so as to give greater chance of a good weld. The process has been described on page 2988. The necessary conditions for a good weld are that the welding surfaces should be as large as possible—hence the sloping, upsetting, or splitting—that there should be no scale or oxide, and that the heat should be sufficiently high. To remove any scale that may exist, welding powders, so-called, are frequently thrown upon the surfaces to be united. The most frequently used powders are boric or boracic acid and silica or sand. The effect of these powders is to form with the scale a slag, which fuses readily, and does not therefore interfere with the process of welding.

No weld is possible with cast iron or steel, the carbon content of which exceeds 2 per cent., as these metals pass quickly from the solid to the molten state and have no plastic stage to give them a possible "welding heat."

Welding Steel. Iron is welded at white heat or a high red heat, but steel must be welded at a lower heat—in fact, the heat of the latter should never be raised higher than the degree necessary to effect a weld, or the quality of the metal is impaired. At the beginning of a steel weld the pieces should be struck lightly, and only after the weld has gone a little way should the sledge-hammer or the power-hammer be used. Steel must be worked quickly on account of the low heat at which the work must be done, and even then it may be necessary to give it more than one heating. The article welded must be annealed after welding—that is, it must be heated slowly to welding heat, and allowed to cool gradually. After being heated, the article may be covered with dry, warm sand, or may be left in the forge until the fire is cold, either method giving the necessary time for cooling; but, of course, the latter is impracticable if the fire is in constant use.

The fuel in heating cast steel for welding purposes should be coke or breeze, and not coal. The steel should be heated quickly, being meantime covered from the air. The welding heat is low, and the metal should not be overheated. Before putting it into the fire, a flux composed of equal parts of borax and washing soda and a little white glass which has been fused together and afterwards ground, should be sprinkled over it, which will dissipate the oxide that may form. Many other fluxes besides that mentioned may be used. One authority recommends a mixture of sulphur,

sal ammoniac, and borax in the proportions of 1, 2, and 10 respectively; while another uses powdered white marble.

In welding cast steel to iron the latter must be raised to a much higher heat than the former. Usually a flux different from that mentioned above is employed. It generally contains a percentage of prussiate of potash with borax and sal-ammoniac. An extensively used French process of welding—the Lafitte—uses plates made of wire gauze covered with the fluxing powder.

Welding Copper and Platinum. Copper for welding is usually heated under the blowpipe instead of in a fire, for the carbon of the fuel would unite with the metal and form copper phosphide, making a solid weld impossible. Copper, particularly at its welding heat, is very soft, and requires careful manipulation, as it does not offer the resistance to blows that iron does. The flux should be applied before the metal is at the proper cherry-red welding heat. It usually consists of soda phosphate and boracic acid in the proportions of 1 and 2.

It is possible, but difficult, to weld platinum, because this metal gives off its heat so rapidly that the heated edges scarcely remain at a welding temperature long enough for the operation. To make an efficient platinum weld it is necessary to have the hydrogen blowpipe playing upon the surfaces during the entire operation. No welding powders are used for platinum.

Autogenous Soldering, or Burning. The process of autogenous soldering, or *burning*, as it is commonly termed, consists in uniting two pieces of the same metal or of different metals by fusing the edges to be joined, and thereby causing them to run together so as to form a strong union. It is more akin to welding than to soldering proper, hence we give it consideration before passing on to discuss the subject of soldering. It makes a much stronger and more intimate union than soldering. No interposing metal is used, hence the expansion and contraction of the finished joint is uniform, and rupture is not likely to take place under any strain insufficient to rupture the solid metal. In soldering, also, the interposed solder is apt to oxidise more or less than the joint, thereby causing weakness; autogenous soldering is free from this objection.

The heat used in autogenous soldering must be intense enough to fuse the metals being operated on. Hence, until recently it has been only the metals with comparatively low melting points that have been "burned" with the help of the blowpipe. But during recent years the oxy-hydrogen blowpipe and the oxy-acetylene blowpipe have been pressed into service for autogenous soldering, so that now even iron, steel and nickel can be successfully joined by burning. We shall consider these improvements in the process when we have discussed its older applications.

We must recognise two classes of autogenous soldering. In one, molten metal the same as that being joined is poured over the edges desired to be joined. It unites with these edges and forms, if thoroughly successful, a homogeneous mass with the work upon which it has been poured. We have seen this process already in the treatment of brass castings which are required in one piece, but are, for foundry convenience, or because of the limited sizes of moulding boxes, cast in two or more pieces [see page 6313]. The process is also used for iron castings, small pieces that have broken off a large casting being renewed by this means, or faulty parts of a large casting being intentionally removed and renewed by pouring molten cast iron around the part, placed in a suitable mould. In these cases the essentials to good work are a properly prepared mould, in which the work is placed, and into which the molten metal may be poured, a high degree of fluidity in the pouring metal, and provision that the first part of the pouring may run out by suitable gates after passing over and heating the surface. Thus, the cold surface is thoroughly heated before the later part of the pouring reaches it; the union by this means is more certain, and stronger. To attempt to use the first part of the pouring before the cold surface had been raised to the point of fusion or semi-fusion would result in a chill.

Pewter and Lead Burning. Pewter work is usually united at the corners by autogenous soldering, especially if the piece be of such a shape as to make soldering from the inside impossible. A small piece of pewter of suitable shape is laid upon the part where the union is to be, and heat is applied with a copper soldering bolt, which is passed over the work until the joint is properly made. The work is then filed and polished. If it has been properly done no joint is visible, and the corner looks as if it had been made from the solid. The heat may be applied by means of a blowpipe instead of with the soldering bolt.

Lead burning is the most common application of autogenous soldering. For lead tanks and lead vessels used in chemical works "burning" is the only proper method of making a joint. The lead to be burned must be scraped clean. For some work, such as lead roofing [see page 5032], it is sufficient that the two edges to be joined overlap a little; but for strong seams, such as are required in the bottom of acid tanks, strips of clean lead are placed above the two butted edges it is desired to join, and the heat, when applied, causes the new piece to fuse on to the top of the other two above the butt. The heat may be applied with a plumber's lamp, or by a blowpipe burning service gas, but the best and usually most convenient method is by a "burning machine" or hydrogen gas generator. This is an apparatus consisting of a lead cistern, into which zinc cuttings are put with diluted sulphuric acid so that hydrogen is evolved, and after passing through a water chamber to be purified is led into an air vessel, which is merely a barrel containing an inverted circular tank of zinc floating on water. A suitable pipe is led from this tank, and by applying a weight to the top of the floating tank or gas bell, the hydrogen is given pressure to send it with the required force through the blowpipe, which is connected to the end of the pipe.

Lead burning may have to be done in work in a horizontal position, working from the top. It may have to be done upon lead in a vertical position, which is much more difficult. It may, finally, have to be done overhead, and this is naturally the most difficult of all. The method pursued may be divided into two classes: surface fusion, which is comparatively simple, and through and through fusion. Lead oxidises rapidly, especially when hot, and oxidised edges cannot be joined so as to give a perfect seam. The outside flame of the blowpipe is an oxidising flame, and the point of the inner flame, which is the point of greatest heat, should be applied to the spot it is desired to fuse. The blowpipe should be brought sharply into position and withdrawn sharply, so that the external flame may not linger upon the lead that is fused or in process of fusion. Some lead burners claim to be able to run down a seam without

withdrawing the flame, but this is neither the usual nor the safest practice. Intermittent fusion is better. Select a point of the work and apply the flame to it until a circle of semi-fusion is made. Then withdraw the flame for a moment and select another point a quarter of an inch along the seam on which to operate. With heavy lead—say over 6 lb.—the seam must be attacked on both sides to make first-class work. When the position of the work makes this impossible, the two edges to be joined should be butted and the edges should be scraped so as to form a V-shaped joint, with the apex of the V where the edges touch. A strip of lead should now be burned on to the recess, the surfaces meanwhile being kept clean by scraping with a shave-hook.

Care should be taken to get a flame of the proper shape. It should be regular, each side of it being the shape of a true arc drawn from the point of issue from the blowpipe to the tip. An irregular flame splutters out in the shape of a horse's tail and has no true point. The proper shape of flame can be got only with practice, and by making the pressure and quantity of both gas and blast proportionate, so as to give the best results.

The Blowpipe. We may consider the blowpipe. It is essentially, in the case we have been considering, an apparatus consisting of an inner or central brass tube, and an outer brass tube encompassing the inner one. The inner tube is connected to the gas supply, in this case the hydrogen generator. The outer tube is connected to an air blast, usually either a fan or foot bellows. The gas coming from the inner tube is ignited, and by causing a blast to issue from the larger and surrounding orifice the flame is directed upon any piece of work to which it is desired to apply heat. The principle is the same whether the fuel be hydrogen, coal gas, oxy-hydrogen gas, or oxy-acetylene gas, the gases in the case of the two last-mentioned being mixed in the blowpipe. The hottest part of the flame is the point of the inner or blue flame, and for work to which it is desired to apply the greatest possible heat the blowpipe is held so that the part of the flame mentioned may impinge upon the work. Most blowpipes have a spring device by which the blast passing up the blowpipe may be regulated in accordance with the requirements of the work.

For small work an ordinary mouth blowpipe is used, and jewellers invariably use such a blowpipe. The heat is the flame of a spirit lamp, and the tip of the blowpipe is inserted into this flame, and the workman, with cheeks distended, blows through the blowpipe, meantime holding the article to which he is applying the heat in the proper position that the flame may be blown upon it. In such cases the article is usually put upon a block of charcoal. An efficient blowpipe device may be made by anyone with a penny candle and the stem of a clay pipe.

Oxy-hydrogen Blowpipe Welding. One difficulty long stood in the way of oxy-hydrogen blowpipe welding—the lack of any known method of producing the gases at economical cost. This difficulty has been overcome by a process recently introduced by Messrs. Braby & Co., of London and Glasgow. The advantages of the oxy-hydrogen flame over the electric arc for welding purposes are that it is under complete control, and that it is not liable to alter the carbon proportion of the steel being welded. The decomposition of water by electrolysis is obviously the most simple manner of securing the two gases, and the apparatus used does this effectively at low cost. Two problems had to be solved in designing the apparatus—the selection of the best material for the electrode plates and some manner of collecting the gases apart. The tank used is 6 ft. long and 18 in. deep, its sides being only $1\frac{1}{2}$ in. apart. A vertical plate of iron is placed the whole length of the thin tank so as to keep the gases apart as they are generated; this plate has a rectangular aperture so as to permit the flow of the electrolyte. The opening at top of the tank is closed with two rubber blocks, which rest between the centre plate and the sides. The sides of the tank are of iron and form the anode and cathode. To the water in the tank is added soda, which liberates sodium and hydrogen at the cathode side and oxygen at the anode side. The sodium, as soon as liberated, decomposes the water in its vicinity, thereby increasing the delivery of hydrogen at the cathode. Water is added continuously by means of a pipe at the bottom of the tank and the gases are led off separately from the top, passing through a 3-ft. water seal, into the gas holders, where they are stored. In each gas-pipe a piece of platinum is kept red hot by electric current, and this provision removes any traces of oxygen from the hydrogen and any hydrogen from the oxygen. At Messrs. Braby's works the current is 200 amperes at 70 volts, and passes through thirty vats in series. The blowpipe, where the gases are burned, is a conical mixed jet pipe with a small brass nozzle. The work done with the oxy-hydrogen blowpipe includes the autogenous soldering of all kinds of sheet-iron work and general repair work of all kinds. The process is used for iron, steel, brass, copper and other metals. One metal may be fused to another by its means. Oxygen and hydrogen are used in the apparatus in the proportion of one to six respectively, and as the decomposition process yields the two gases in the proportion of one to two, there is excess of oxygen, which is compressed into cylinders and sold for medical and other purposes.

In autogenous soldering of iron and steel by the oxy-hydrogen or oxy-coal-gas, difficulty is experienced owing to the oxidation of the iron by the steam produced in the flame. A French precaution to avoid this oxidation consists in the addition to the coal-gas or hydrogen of a hydrocarbon rich in carbon, substances such as acetylene or the vapour of light petroleum being used. It is claimed that by this means the products of combustion contain less steam and more carbon dioxide; also that the latter is partly dissociated with formation of carbon monoxide, which has a reducing action, and thus prevents oxidation of the iron.

Oxy-acetylene Welding. The use of oxygen and acetylene in a special blowpipe for supplying the heat necessary in autogenous welding is a recent development and has many advantages. Pioneers in the manufacture of apparatus for this work are the Thorn and Hoddle Acetylene Company, of London. The oxygen is contained in a cylinder, where it has been compressed to 120 atmospheres. The acetylene is generated in an "incanto" generator, and after passing through a purifying apparatus is led into a gas-holder, where it is retained under a pressure of 6 in. of water. With the oxy-acetylene blowpipe it is found, in practice, that the best welding results are obtained by a mixture of 1 volume of acetylene with 1·7 volumes of oxygen. The flame produced has in its centre a small white cone, at the apex of which the temperature is about 6,300° F. This flame consists almost entirely of carbon monoxide,

which is being converted at its extremity into carbon dioxide. Round the flame is a relatively cool jacket of hydrogen, which, not being able to combine with oxygen at the very high temperature in the immediate neighbourhood of the flame, remains temporarily in the free state, and thus protects the inner zone from loss of heat while excluding the possibility of oxidation, which is a difficulty other methods of welding have to contend with.

The heat, in addition to being greater than that obtained by any other blowpipe system, is also more concentrated. The gases are mixed in the injector chamber before they issue from the nozzle of the blowpipe. Work with this blowpipe is rapid. A good workman can make a weld of 15 ft. per hour, working on a $\frac{1}{4}$-in. steel plate, or of 6 in. per hour on a $\frac{1}{2}$-in. steel plate. Oxy-acetylene autogenous welding has been successfully applied to a wide variety of work, such as cycle parts, welded boilers, steel safes, tanks, tubes, and all classes of copper work.

Aluminothermy. The introduction of aluminothermy in the process of welding or autogenous soldering a few years ago attracted more attention than any other process in the same department of industry for many decades. It ranks in importance with electric welding, and is much wider in its application. A brief introduction is necessary to enable the basic principle of the process to be understood. All chemical reactions are accompanied by the absorption or the liberation of heat. Mix sulphuric acid and water and observe that considerable heat is evolved; indeed, the heat may be so great as to cause an explosion, and it is much safer to add the sulphuric acid gradually to the water. The manufacture of aluminium from the oxide demands great heat and the commercially successful process of making aluminium is by the electric furnace [see page 5989]. This heat, or a great part of it, is absorbed by the metal, and becomes latent heat, which may be given off again if the proper method of causing this liberation of heat is known. It was the discovery of the method of achieving this end that brought aluminothermy into the realm of everyday industrial processes.

Oxide of aluminium is formed with very great heat, but the oxidation of aluminium at ordinary temperatures is negligible. If, however, the oxidation is started at a sufficiently high temperature, it will proceed rapidly until the whole mass of metal is reached. This reaction depends upon the fact that aluminium gives out very great heat as it combines with oxygen, for which its affinity is very great. So great is this affinity that the metal will reduce all other metallic oxides to their metals.

Thermit. In practice, the material used in aluminothermy is a compound sold under the proprietary name of *thermit*, and is made and sold by Thermit, Ltd., of London.

It is a compound of finely divided aluminium and a metallic oxide, usually oxide of iron. The heat evolved is so great—it exceeds even that of the electric arc—that special crucibles and special methods are necessary in the practice of aluminothermy. The crucible usually has the shape of an inverted cone, and is made of iron sheet with a magnesia lining, and a sheet-iron hood, which prevents sputtering during the reaction. The bottom—that is, the apex of the inverted cone—has a round hole into which is fitted a tapping bar, which is merely a short iron rod. Above this tapping bar is placed a sheet-iron disc made to fit the bottom of the crucible, and above the disc is placed a piece of asbestos with some fireproof material tamped in above it.

The thermit is placed in the crucible, into which the tapping bar has been fitted as described, and the mass is ignited by the use of a special ignition powder. Then the reaction begins, and proceeds rapidly until the aluminium is burned to aluminium oxide, and the iron remains in the pure state, being in reality a very low carbon steel, usually with about ·1 per cent. of carbon. Then the reaction subsides, and with a rod the tapping bar is dislodged upwards and pushed into the intensely hot body of molten iron, where it is instantly reduced and incorporated. The mass flows out through the tapping hole into the mould prepared for it, where it settles upon the surfaces it is desired to weld or unite.

Uses of Thermit. The most frequent use to which thermit has been put is in the welding of tramway rails. It welds rail end to rail end so that the whole rail system of a tramway service may be welded into one entire length of rail. It is possible to follow this practice for tramway rails where the rails are bound into position by paving blocks, but for the permanent way of our railways, where the rails have no such binding, welding is impracticable on account of the bending that would ensue when the rails were elongated by heat.

There are many other uses for thermit. They lie chiefly in foundry practice, for burning castings together or for renewing faulty parts of castings. In marine repair work the process has saved many thousands of pounds, as by its means a shaft or other piece of marine engine mechanism may be repaired at once, and so enable the vessel to put to sea, or proceed without the delay that would be caused by the older method of making a duplicate part.

Crucibles and Moulds. Several other considerations may be mentioned before we leave the subject of thermit welding. The crucible we have described is tapped from the bottom by the method described. The use of such a crucible is imperative, because lip pouring is impossible. The slag which forms upon the top adheres to anything which it may touch, and if a little slag entered with the poured metal it would prevent proper adhesion and spoil the work. The mould must be made so that the first part of the metal will run to waste, heating the parts to be united before it does so. Also the moulds must be made as for high-grade steel castings, and the faces finished with a wash of silica, or of silica and plumbago. They must be thoroughly dried, and slowly heated to red heat so as to make them quite free from moisture. The thermit must not be poured at too high a temperature. It is usual to allow the heat to subside a little after the reaction has ceased, and it is also customary to throw into the crucible some soft steel punchings and to permit these to melt before tapping.

We have described only a small part of the field in which thermit is used. For the rest we must be content with mentioning a few of its applications without detailed description. In steel castings, thermit may be placed in the riser, the heat of the molten steel being sufficient to ignite it. It raises the temperature of the pouring, enabling smaller risers to be used, and keeping them open longer. The same process is sometimes used for cast iron, but as the heat of cast iron is not high enough to start the reaction, some ignition powder

must be placed along with the thermit. It is also introduced into steel castings to prevent "piping"—that is, the formation of a large shrink hole near the top of the casting. In such a case the thermit is introduced just before the casting becomes solid; it makes the steel more fluid again, and permits the gas to escape before final solidification.

Electric Welding. The process of electric welding permits welding to be applied to the union of many metals which could not be united by the ordinary process of welding as already described. Given the proper appliances, the operation of electric welding does not require the high skill born of long practice that ordinary welding demands. The intelligence has been put into the machine, and man's part becomes to an equivalent extent mechanical. The work is secured in clamps, through which the current passes, the surfaces to be joined being opposed to each other. As at the point of contact there is more resistance than there is through the solid metal, heating takes place, and as the metal becomes soft the clamps are made to exert pressure towards each other, and the weld is made by this pressure. The Thomson process of electric welding is that usually followed, and the makers of the machines for this process are the Electric Welding Company, Ltd., of London.

In electric welding it is desirable that there should be a good deal of work of one class, because the machines are limited in the scope for which they are fitted. The power required to raise the metal to welding heat is very great during the time it is called into action, and the machines are graded by the cross sectional areas they can undertake and the horse-power of the generator. Thus only work of approximately the same sectional area is suitable for one machine. Angle iron could not be welded on a machine for wire, for instance.

Sometimes the electric currents used are as high as 50,000 amperes; but the electromotive force is only half a volt, so that little danger attaches to their use. Alternating-current generators are used, and if a direct current only be available a motor alternator must be installed.

The weld begins in the centre and extends towards the surface as the temperature rises. The resistance of the hot metal, being higher than that of the cold metal, draws the heat to the desired parts. When the welding heat has been reached, the ends are pressed together as already stated. The pressure is given either by manual or hydraulic power. The machines have been developed very much in the direction of making them automatic.

Value of Electric Welding. The quality of the work done by electric welding is more likely to be excellent than work performed by hand welding. From the point of view of economy, the former has everything in its favour when output is large. Its sphere, however, does not lie in small or in general work, but in repetition work. The economy secured by electric welding is caused largely by the absence of special preparation of the work—such as sloping, upsetting, and splitting—which often make a union demanding a somewhat lengthy drawing out and finishing. Work for which electric welding is specially suited includes chain manufacture, cycle components, carriage work, and tools such as axes, where the poll of mild steel is electrically welded to a tool steel edge. The speed with which the work can be carried out is surprising. Tests made show that iron and steel pieces of 4-in. sectional area can be welded in 90 seconds with a horse-power expenditure of 83·8, and a copper weld of 1-in. sectional area takes 23 seconds, with almost the same horse-power expenditure. An additional value of the process lies in the fact that dissimilar metals can be united by its agency. Iron, wrought or cast, can be welded to zinc or copper, for instance.

Soft Soldering. Soft solders melt at comparatively low temperatures. It is possible to use them with nearly all metals. In the operation of soldering there are three necessities: the means of applying the heat sufficient to fuse the solder, the solder itself, and the flux, which enables the solder to associate itself intimately with the metal or metals to which it is applied. The further apart the melting points, the hardness, and the malleability of the solder and of the metals being soldered are, the weaker is the union. Thus, a soft soldered joint in iron, brass and copper is always comparatively weak. It may have some strength if the metals joined by soldering are comparatively thin, so that they can bend under any stress to which the joint may be subjected, thereby relieving the solder of the duty of resistance; but if the metals be heavy and inflexible a blow or other act of violence may cause disruption of the union. Soft solder, again, having properties not far removed from those of tin and lead, makes a strong union with these metals, which, when soft soldered, may be hammered and worked with comparative freedom. This point has much to do with deciding the method of soldering to be adopted in any particular case.

In soft soldering the usual way of applying the heat is by means of the tool known as the *soldering iron, soldering bolt* or *soldering bit* [see page 5030]. This tool is a short, square bar of solid copper drawn to a point and mounted on an iron rod, which is provided with a handle. Its point must be covered with tin before being used. To tin it, it is heated in a stove or fire of any sort until it is dull red; it is then filed slightly so as to clean the point, and is rubbed first against a piece of sal ammoniac and then upon some solder placed upon a copper or tin plate. It is then ready for use. In the actual operation of soft soldering the surfaces to be united are first cleaned if necessary—diluted hydrochloric acid applied with a brush or cloth is usually employed—then the flux is applied to the surfaces, and finally, the hot soldering bit, after being rubbed against the solder so as to take on a small quantity, is rubbed over the flux and the joint is made. The flux and the solder may vary in composition and depend upon the nature of the metals being soldered. We shall consider them presently.

Soft soldering is often done by means of a blowpipe instead of a soldering bolt, particularly by gasfitters and pewterers. A plumber's soldering lamp may be used, or expert workmen may burn some rushes or wood chips around where the joint is to be made, directing the flame by means of a blowpipe. The flux is, of course, used as with the soldering bolt. Gasfitters use a solder rich in tin and a flux made of oil and resin mixed in equal proportions. Pewterers use a solder containing bismuth, which is more easily fused than most soft solders, and as flux they employ Gallipoli oil, which is a green olive oil.

Soft Solders. The most commonly used soft solder consists of one part of lead to two parts of tin. "Plumbers' sealed solder," so-called, is two parts of lead to one part of tin, and is fusible at a considerably lower melting point [see page 5987]. The solder consisting only of lead and tin, and

COMPOSITION OF SOLDERS

Purpose.	Composition.								Flux.
	Tin.	Lead.	Copper.	Brass.	Zinc.	Silver.	Gold.	Bismuth.	
Plumber's ordinary	1	3	..	..	..	..	..	..	Resin.
,, sealed ..	1	2	..	..	..	..	..	..	,,
,, fine	1	1	..	..	..	..	..	..	,,
Tinman's solder ..	3	2	..	..	..	..	..	..	Resin or zinc chloride.
,, fine......	2	1	..	..	..	..	..	..	,,
Hard solder for iron, copper, and brass	..	..	2	..	1	..	..	..	Borax.
Spelter solder......	..	..	1	..	1	..	..	..	,,
,, but more fusible ..	..	..	1	..	1	..	..	..	,,
Pewterer's solder ..	3	4	..	..	..	..	..	..	Resin or zinc chloride.
Bismuth solder	1	1	..	..	..	..	..	1	,,
For gold	..	..	4	..	..	2	12	..	Borax.
,, another	..	..	1	..	..	2	24	..	,,
For steel	..	..	3	..	1	19	..	..	,,
For aluminium-bronze..........	..	..	1	..	..	4	..	..	,,
For silver	..	..	1	1	..	19	..	..	
Fusible solder for meat tins	16	10	..	..	..	..	..	1	Resin.

In this table the solders of which borax is given as the flux are hard solders, and those of which resin or chloride of zinc is the flux are soft solders.

Manufacturing Soft Solder. Soft solder should be made in a porcelain or stone vessel, because in an iron pot the solder may absorb some of the iron. First melt the tin and then add the lead gradually in small pieces, stirring with a wooden stick. When the whole is fused and thoroughly mixed the alloy is poured into moulds, usually short bars about 8 in. long, from $\frac{1}{2}$ in. to 1 in. broad, and from $\frac{1}{4}$ in. to $\frac{1}{2}$ in. thick. Suitable moulds may be made by taking a mass of clay, beating its top flat and pressing into it in various places a stick of solder, thus making depressions into which the new solder may be run.

Fluxes. Soldering fluxes are numerous. The plumber uses both resin and chloride of zinc. For electrical work chloride of zinc is frequently forbidden, but is still used to a fair extent. For the meat canning industries, also, chloride of zinc is supposed to be harmful but is still greatly used, sometimes unknown to those who use it and who purchase chloride of zinc solution under a proprietary name. To make chloride of zinc solution, or *killed spirits*, as it is called, dissolve zinc in hydrochloric acid, or spirit of salt, as it is commonly termed, putting in more zinc than the acid will dissolve, so that the solution may be saturated. The ebullition may be too violent with pure hydrochloric acid, and water up to two parts to one part of acid may be added. The zinc should lie in the acid for at least twenty-four hours, when any excess of zinc may be removed, and the soldering liquid is ready. It is bad to use scrap zinc as it may contain iron, which is deleterious, and scrap zinc is always dirty. The solution may be filtered with advantage. Sometimes other substances, such as sal ammoniac or glycerin, are added in small proportions and are held to improve the fluid. This flux will suit nearly every purpose. For iron it requires to be stronger and may be used without water. For soldering galvanised iron—an extremely difficult operation and not a pleasant one—this flux would cause adhesion only to the zinc coating, and, therefore, raw spirit—that is, pure hydrochloric acid—is used to remove the zinc, after which the above mentioned solution may be used to solder to the iron. Tallow and other oils and fats are used to a fair extent as fluxes. Lard oil is used to solder aluminium with fair success, but the soldering of aluminium is a difficult matter, which we shall consider separately. Gallipoli oil is used by pewterers, as already mentioned.

For copper and sheet iron a flux frequently employed is powdered sal-ammoniac or an aqueous solution of it, followed by resin. Sometimes the powdered sal-ammoniac and resin are mixed before application. It is extremely difficult to solder zinc as it removes the tin from the soldering bit very quickly, making frequent retinning necessary.

Before passing from the subject of fluxes we may notice a few that are put forward as having specific merit, although they give no promise of deposing chloride of zinc as the all but universal flux. The proprietary fluxes sold under fancy names we leave alone; they are almost without exception solution of chloride of zinc prepared as we have described above.

A soldering paste is made by mixing chloride of tin with starch paste. A soldering fat is prepared by heating two parts each of olive oil and tallow and by adding one part of powdered colophony: then, after the mixture has been stirred and has boiled up and cooled, one part of a saturated aqueous solution of sal ammoniac is added. Phosphoric acid in solution with water or spirit is also used.

Soldering Without a Bit. By careful manipulation the operation of soft soldering may be performed without a soldering bit. A lamp or gas jet may be used to make the surfaces hot, the flux is then applied, followed by the solder, and with skill a successful joint is achieved. If two pieces of brass or copper be filed to fit each other, covered with a soldering fluid, and have a piece of tinfoil interposed, thereafter being heated over a gas jet or fire, a union will result, the tinfoil fusing and joining the two surfaces.

Hard Soldering. Hard soldering is the process of joining two metals or two pieces of the same metal by a solder that has almost as high a

melting point as the metals joined. The term *brazing* is generally applied to this kind of soldering. The heat of the copper soldering bit used in soft soldering is not sufficient for hard soldering. The work is sometimes done in an open fire such as a smith's forge, but the usual process is to raise the heat by a blowpipe, using gas as a fuel and applying the blast either by a power-driven fan or by hand or foot bellows. The most usual and convenient way, especially in small shops, is by the use of a brazing forge with pedal bellows. The workman can then use both hands in controlling the application of the heat. Sometimes the bellows are replaced by a rotary fan for supplying the air blast, and either method is satisfactory.

Sometimes, again, a plumber's lamp may be used, but this is not so satisfactory, as the heat cannot be raised so high as with gas, and good work is not so certain. Some large firms—such as cycle manufacturers—who have much and constant brazing work of one class, have the hard solder in a molten bath and dip the work into this bath. This process is unsurpassed for the quality of work produced, but it necessitates more finishing than is required by the blowpipe method, as the molten solder adheres to a larger area of the work than is necessary to make the brazed or hard-soldered joint.

Hard Solders. In the table already given appear some recipes for hard solders. Such solders are, for convenience, divided into three classes—brass solders, which are used with steel, iron, and copper; argentan solder, used for German silver; and gold and silver solders used for these metals. The common composition of solders of the first class is 8 parts of brass to 1 part of zinc. Refractoriness is increased by lowering the proportion of brass and adding tin. Thus, a composition with 6 parts of brass and 1 part each of tin and zinc is much used where a more refractory solder is desired, and this may be made still more refractory by adding 1 part of copper. By increasing the tin, the ductility decreases and the colour tends to grey. For work where the joint has to withstand bending stress, a high percentage of tin is to be avoided, as it causes brittleness.

Making Hard Solders. In making hard solders it is advisable to use brass instead of its constituent metals—zinc and copper—because the loss of zinc when fusing the metals separately is uncertain, and because by using brass already made this loss is minimised very much. Sheet brass is better than cast brass as an ingredient in hard solder, because the rolling has imparted to it a higher degree of homogeneity than is possessed by cast brass.

First melt the brass at a strong heat, and in another crucible melt the zinc that is being added as such, also at a strong heat. Pour the molten zinc into the molten brass and stir the mixture well. Then the solder is ready to be poured, and there are several ways of doing this, the object of all being to obtain a fine granular product suitable for soldering. Sometimes the molten alloy is poured through a wet broom into cold water, this separating the metal into the granular particles desired. A better method requires a cistern placed so as to give a good head of water, and an orifice that projects a stream of water horizontally over a water-tank. The molten alloy is poured on to this horizontal jet of water, which divides it, and the grains fall to the bottom of the tank, whence they must be taken and dried before they have time to oxidise. By varying the strength of the water-jet and of the metal-pouring, it is possible by this method to make grains approximately of any desired size.

Argentan solder is used for German silver, and also for steel and other work, the joints of which are required to be very solid. A readily fusible argentan solder is made of copper 35 parts, zinc 57 parts, and nickel 8 parts. A more refractory composition contains copper 38 parts, zinc 50 parts, and nickel 12 parts (Brannt). A general rule is that the higher the percentage of nickel in the German silver to be soldered, the higher is the proportion of nickel in the solder. The composition is cast in thin plates, which are broken and beaten in a heated iron mortar, so as to make them into a powder. If it is found to powder easily, it has too much zinc, and if the operation is too difficult, it is deficient in that metal; if it shows either fault, it must be remelted and the fault remedied.

Gold and silver solders are used chiefly for soldering these metals, but are also used for articles to be enamelled, for bronze, cast-iron, etc., but on account of their expense their use is naturally limited to work of a high-class nature. A few recipes for these have been given [see also page 5857].

Fluxes for Hard Solders. The most generally used flux for hard solders is borax. The purpose of the flux is to remove the layer of oxide upon the surfaces it is desired to solder, and borax is the best all-round agent for this. It effects its purpose by reason of the excess of boracic acid which it contains dissolving the layer of oxide. For higher temperatures, finely powdered glass of a fusible nature may be used. For soldering copper, phosphate of soda or phosphate of ammonia may be employed. Quartz sand mixed with decomposed soda, or, for very high temperatures quartz sand alone, is satisfactory. For coarse work, turpentine or olive oil mixed with sal ammoniac is a good flux. A solution of carbonate of ammonia (saturated) is used for brass. A liquid flux, known as *hard-soldering fluid*, is made by dissolving phosphoric acid in alcohol. Many other fluxes are employed with satisfactory results, preference attaching universally to no particular agent, even for the same metals. It is largely a matter of experience and individual liking.

Soldering Iron and Steel. All metals are not equally satisfactory under treatment by the ordinary processes of soldering, and special measures are often required. We shall review the best processes of treating such metals.

Cast iron is frequently considered unsatisfactory under any process of soldering, but it is not so. It is frequently desirable to solder cast iron, especially in altering cast-iron foundry patterns. For this purpose, soft soldering imparts all the strength necessary. The surfaces to be soldered must be polished bright. Then dip the surfaces into potash water, and upon withdrawal dip into clean water, after which apply quickly undiluted hydrochloric acid. Then sprinkle with powdered resin and solder with the bit in the usual way, using any soft solder, but for preference one made of equal parts of tin and lead. The operation must be performed quickly before the surfaces have time to dry. A more refractory soldered joint may be made with iron or steel, by using copper or brass as the soldering medium. The surfaces are first filed or polished bright, and are tied into position with wire. Then upon the joint place a thin strip of copper or brass. Cover the whole with a good layer of clay containing no sand, and place it near a fire that the clay may dry. Then put the part to be soldered under the blowpipe and raise it to white heat. This causes the clay to vitrify, thereby forming a flux. If the metal being soldered is iron, it is cooled in water,

but if steel, it is allowed to cool slowly. Then the clay is removed and the joint has only to be cleaned. When the soldering medium is a copper strip, it requires a stronger heat than a brass strip, and the latter is therefore more frequently used for soldering steel. For small pieces of iron, a silver solder—equal parts of silver and soft brass—may be used; it is used as foil, and, after annealing, is placed upon the surfaces to be soldered, borax being used as the flux, and the heat being applied with the blowpipe.

A short time ago some tests of hard solders on steel and iron were made at the National Physical Laboratory. Of five solders experimented with, the best was found to have the composition—copper, 63·19 per cent; zinc, 36·31 per cent.; and lead, ·65 per cent. A conclusion drawn from the tests was that the quality of solder improves with the copper percentage. The solder that stood the tests most satisfactorily had the highest proportion of copper, and was as stated above. At what point the improvement of quality ceases by increasing the copper—for, of course, there is such a point—was not determined.

A German patent (E. Herzog, 6th May, 1902) makes a soldering paste for cast iron by mixing pure steel or iron powder, free from oxides of iron, with stearin or paraffin oil, borax, and camphor. A suitable mixture is steel or iron powder 80—120; paraffin oil 10—30; borax 30—50; camphor 1—4. The parts to be joined are well cleaned, coated with the soldering paste, and after addition of borax and solder are heated to redness, usually under the blowpipe.

The work of soldering or brazing saws is a common operation with saw doctors, and it is essential with band-saws. File the two ends to be joined smooth and tapering, so that one overlaps the other some distance. Tie the ends together with wire, so that they will retain their proper position during the operation. Apply to the joint some borax, reduced to a cream by rubbing it with water on a slate. Now sprinkle some brazing spelter over the joint and apply the blowpipe heat, until it is seen that the spelter has run into the lap. Allow the work to cool gradually, and finish by filing.

Soldering Zinc, Brass, and Silver. In soldering zinc and galvanised iron, the soldering bit must be kept very hot, and the flux used is hydrochloric acid, undiluted, or diluted with only one third of its volume of water.

The soldering of brass is made more easy if the surface has been previously tinned. This is easily done. Clean the surface, apply borax paste, prepared as already indicated, and place upon this a piece of tinfoil. Heat until the tinfoil fuses and runs over the surface. The solder adheres uniformly and tenaciously to surfaces treated thus. A good solder for brass is a soft spelter—commonly called Bath metal solder—consisting of 21 parts of copper to 79 parts of zinc.

Brass and steel may be soldered together by first coating the steel with a solution of sulphate of copper, and then by soldering the two surfaces in the usual manner.

Silver is soldered with an alloy containing 19 parts of silver, 10 of brass, and 1 of copper. This is reduced to granular form by the process already described, or if for fine work is made into powders by filing it. The flux used is borax, which should be rubbed with water upon a slate or hard stone, so as to make a cream, which is applied to the two surfaces with a brush. The powdered solder is then applied between the pieces, and the work is laid upon a charcoal block, where the heat is applied with the blowpipe. When the union is made, an immersion in pickle removes the excess of borax, and the work is finished.

Soldering Aluminium. A fortune lies at the feet of any man who can find a simple and efficient method of soldering aluminium. Many attempts have been made, and workers in aluminium have had their hopes raised many times that the problem had been solved, only to be dashed again. No economical process of soldering aluminium has been proved to be permanently successful [see also page 5991]. The film that always lies on the surface of aluminium is an oxide that forms immediately the metal is exposed to the air. The oxide can, of course, be removed by filing, but a new film of oxide forms instantly upon the new surface created by the file. It has been found possible by ordinary soldering to make what appeared to be a satisfactory soldered joint with aluminium, but the lapse of a few months has always shown it to be otherwise, and the union has been found to be faulty. It is for this reason that commercial articles of aluminium are never, or almost never, sold with soldered joints. Usually the articles are cast or pressed and drawn from one piece of the metal, or if it is necessary to join one piece to another, or another metal to aluminium, riveting or screwing is the method employed. Still, we can indicate some of the solders used for aluminium when attempts are made to solder it. One solder is composed of 1 part of zinc to 4 parts of tin, and the flux recommended for it is made of 1 part each of tin chloride and zinc chloride, and 8 parts of stearic acid. Another worker professes to have achieved success with lard oil as a flux. The aluminium is usually heated with a blowpipe, and kept hot during the operation. The copper soldering bit is said to discolour the aluminium, and a nickel soldering bit is recommended. Other solders for aluminium contain that metal as a constituent. Horner, in the "Encyclopædia of Practical Engineering," gives the following recipes for aluminium solders:

1. Aluminium 2·38; zinc, 26·19; tin, 71·19; phosphorus, 0·24.
2. Aluminium, 6; copper, $4\frac{1}{2}$; zinc, $89\frac{1}{2}$.
3. Aluminium, 6; silver, 3; copper, 3; tin, 18; zinc, 9.
4. Bismuth, 6; tin, 94.

Soldering Metal to Glass. Glass may be soldered to metal by first coating the former with lead or with amalgam. The glass to be coated with lead is coated on one side with chalk and water, and after drying is placed clean side up, and fixed down in a special cast-iron tray, which is then placed in muffle surfaces and heated until the glass is at about 650° F., just above the melting point of lead. Then molten lead is poured over so as to cover the glass, and the tray is oscillated for some time. Then the lead is allowed to run off, and leaves a layer upon the exposed surface of the glass. This process is used in the manufacture of glass buttons, in order to allow the stems to be soldered to them.

Continued

UNDERGROUND WORK

Laying Telegraph and Telephone Lines Under the Streets. Conduits. Manholes. Pipelaying. Cabling and Jointing

By D. H. KENNEDY

AERIAL conductors have, broadly speaking, two principal advantages over the underground method of construction—namely, low cost and, owing to the small electrostatic capacity, high efficiency as electrical conductors; but these are frequently outweighed by other factors, which lead to the substitution of subterranean routes.

In large cities, overhead routes are generally unobtainable; moreover, when some degree of conducting efficiency can be sacrificed, and where the number of conductors is large, the underground system may be found to be cheaper, especially when the cost of subsequent maintenance is taken into account. Maintenance, which is heavy in the case of aerial wires, may, by good first construction, be reduced to insignificant dimensions in the case of underground work. Until about the end of the last century wires insulated by a covering of gutta-percha were almost invariably used. These were placed in iron pipes of 2 in. or 3 in. diameter, with joint boxes at suitable intervals. When telephone circuits were concerned, the wires were made up in fours twisted together to form a "quad" cable. A 2-in. pipe could take seven, and a 3-in. pipe nineteen of such quad cables, and as they could not be drawn in over each other it was necessary either to fill the pipe at one operation, or in cases where this had not been done, to draw out one lot before pulling in another.

These G.P. wires had conductors of 40 lb. copper insulated with 50 lb. of gutta-percha to a diameter of 174 mils (the mil is $\frac{1}{1000}$ in.), and not more than eighty wires were ever pulled into a 3-in. pipe.

Cables. The invention of the dry-core cable has, however, revolutionised affairs, and it is safe to say that the present highly developed underground telephone systems would have been impossible without it. In this form of cable the wires are wrapped in paper, but the real insulator is dry air. The electrostatic capacity is one-fourth that of gutta-percha cables. The paper-covered wires are enclosed in a tube of lead, but the economy of space is such that a 3-in. iron pipe will accommodate a lead-covered cable containing 182 40-lb. conductors, as compared with the eighty gutta-percha-covered wires already mentioned.

Post Office London Underground System. It is probable that a description of the methods adopted by the Post Office in laying down their huge underground system will best enable the student to comprehend this subject. Beginning at the exchange, we have first the main conduit routes. These are laid along the centre of the main thoroughfares, and contain ducts varying from six up to any required number.

Earthenware Ducts. The ducts are made of earthenware, 18 in. and 24 in. in length, with internal circular section 3¼ in. diameter, and external hexagonal section 4½ in. diameter. In building a duct route, the ground is first excavated, and, if necessary, shored up; a 6-in. concrete foundation is then laid, having embedded in it T-irons laid lengthwise under every alternate line of ducts. These are 2½ in. by 2½ in. by ¼ in. thick, and they are employed to resist the vertical displacement stress. When the concrete has set, the layers of ducts are put down, bedded in cement mortar. As in the case of succeeding lines of brickwork, the ducts are arranged so that the joints in one line do not coincide with those in adjacent lines.

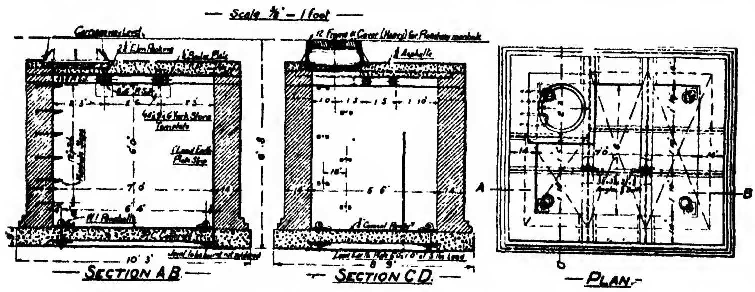
To facilitate jointing, wooden mandrels are used, 11 in. long and 3⅛ in. diameter. When a joint is being made, the mandrel is arranged so that one-half of it is in each of the abutting ducts. A strip of prepared calico, which has been soaked in ozokerit, to make it adhesive, and which is 20 in. long by 4½ in. wide, is then wrapped tightly round the joint. The mandrel is then drawn forward. Such joints can be made rapidly, and a train of a dozen mandrels is usually employed. Of course, it is absolutely essential that the ducts shall not be deflected during the subsequent operations, and once the cement mortar has set the permanence of the whole system is assured. When all the ducts required are in position, concrete is added to the sides and top, and the roadway filled in and reinstated.

Manholes. At intervals of 150 yd. to 180 yd. manholes are provided to house the joints. If possible, the junction of thoroughfares is chosen as the position. These roadway manholes [33] have to be of substantial construction, a need which is emphasised in these days of heavy motor traffic. The minimum dimensions are: length 4 ft., width 4 ft., height 4ft. 6 in., and these are increased as required, a very common type being 8 ft. by 7 ft. by 5 ft. 6 in. The method of construction may be briefly described as follows. The trench is widened and deepened, and a 6-in. floor of concrete laid down, but with the thickness at the sides extended downwards to 9 in. to form footings for the walls, which are of 14-in. brickwork. An earthplate of 5-lb. lead, 6 ft. long by 1 ft. broad, is laid under the concrete, to be subsequently connected to every cable sheath by a 1-in. strip of lead, which is taken up the inner wall of the manhole. Provision is also made for the subsequent drawing in operations by embedding in the concrete in each corner heavy wrought-iron ring-bolts, with large anchor plates bolted on below the concrete. When the concrete has set, the walls are built. Galvanised iron footsteps are built into the corner, above which the entrance is to be placed, and when nearing the roof-line, the stone templates which form the supports for the roof joists are carefully set in position. The roof is as simple in construction as it is strong. The width of the manhole is bridged by rolled steel joists of 8 in. by 6 in. section. These, in turn, are connected together, and to the walls at each side, by smaller rolled steel joists (4 in. by 3 in.). Resting on these is placed a roofing of ½-in. boiler plate. Above this comes 6 in. of concrete, and then a layer of asphalt. Above this the road is made up in the ordinary way, except at the entrance corner. Here a heavy cast-iron frame, 12 in. deep, is provided, into which fits a similar lid, having its upper surface filled in with wood blocks set in pitch. The

inner walls of the manholes are carefully pointed, and the floor covered with a ¾-in. rendering of Portland cement. Figure 33 gives details of a typical manhole.

Distribution Pipes. While it is necessary to have the main routes in the roadway, the distribution pipes must be as near to the shops and houses as possible, and they are, therefore, run along the footpaths. For this purpose, cast iron pipes are used. These are classified according to their internal diameters, as 2-in., 3-in., or 4-in. The first-named are made in 6-ft. lengths, the others in 9-ft. lengths, and the respective weights are 42 lb., 98 lb., and 154 lb. A 3-in. pipe placed on supports 5 ft. apart will support a ton and a half, and a jointed pipe similarly tested will support a load exceeding a ton. They are coated with Dr. Angus Smith's composition, which prevents rusting, and gives a glazed surface. Figure 34 illustrates such a pipe. The left end is called the spigot end, and the right end the socket end. Bends of convenient dimensions are also provided. In laying a line of distribution pipes great care has to be exercised in the choice of the route. Allowance must be made for existing gas, sewer, electricity, hydraulic, and other mains, and in many cases the existence of under-footway coal-cellars makes special difficulties. Very often the line nearest the house-line is found to be the best, because not only is it most economical for distribution, but, owing to the fall of the paving to the roadway, the distance from cellar top to paving is here at a maximum. Ten men form a convenient gang, and when the foreman has chalked out the route, the paving is taken up, great care being exercised to avoid breakages, and the stones (where York or artificial stone is concerned) being laid so as to enable them to be returned to their original positions. While the first dozen yards of trench is being excavated the jointing of three lengths of pipe is in progress. For this purpose four blocks of wood, with V-slots in them, are set up at (for 3-in. pipes) distances of about 9 ft. The spigot end of the second pipe is fitted into the socket of the first, and so on with the third, but before being brought together, they are carefully gauged and examined to see that their interior surfaces are in order.

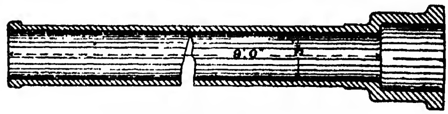
Into the annular space between the spigot and socket a length of spun yarn is inserted, being first wrapped round the spigot and then driven home by a caulking iron. Meantime, a roll of clay has been prepared by wetting and rolling on a board, and this is placed under the pipe and round the mouth of the socket, the ends being brought up above and curved outwards, so as to leave an opening into which molten lead may be poured. The space between the yarn and the clay is in this way filled with lead, which efficiently joints the two lengths of pipe.



33. GENERAL CONSTRUCTION OF CARRIAGEWAY MANHOLES

The clay is then removed, to be used again, and the cooled lead tightly caulked. A level bed having been prepared in the trench, small holes are made to receive the sockets, and the pipes are lowered into position. One joint in every four has to be made in the trench. A No. 8 iron wire is threaded through the pipes length by length as they are laid to be used in the drawing-in of the cable.

Under fair average conditions, a good gang can lay 100 yd. in a day of 9½ hours. Footway jointing chambers of various sizes are provided at intervals not exceeding 100 yd., but they are usually required at more frequent intervals for distribution purposes. Six sizes are in use, varying from "double junction" boxes 4 ft. 2 in. by 1 ft. 11 in. down to "distribution" boxes, 1 ft. 2 in. by 8 in. A concrete floor with Portland cement rendering is provided, and the sides built up of brick, the box proper being merely an iron frame designed to hold the iron lid, the top of which is filled in with stone. The connection between the footway boxes and the subscribers' premises is made by a length of 1 in. pipe. The connection between the roadway manhole and each of the adjacent footway junction boxes is in all cases made by three lengths of pipe.



34. DISTRIBUTION PIPE

Cable System. Having disposed of the pipes, we may now consider the cables more fully. It has already been mentioned that a short length of silk and cotton insulated cable connects the street cable to the main frame. This is for convenience of handling. The joint between the silk and cotton cable and the paper insulated cable is made solid by filling up the lead sleeve with molten insulating compound and allowing it to solidify.

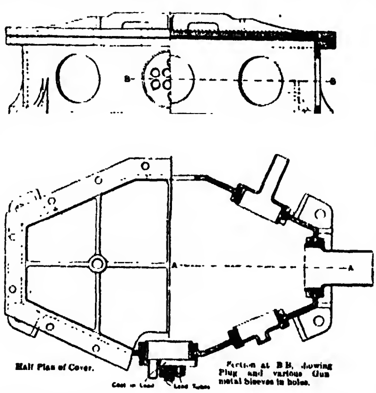
The main distribution cables are varied in type according to the purpose in view.

For serving subscribers near at hand, cables containing 1,212 wires of 10-lb. conductor are used. For the next ring, 750 or 606 wires of 12½-lb. conductor, while for the general case the standard cable is one of 434 wires of 20-lb. conductor. All these go into 3-in. or 3¼-in. pipes, so that the first-named enables us to imagine 606 separate conversations taking place through a 2¾-in. diameter circular space.

From the exchange basement the main cable runs through the ducts to the point where it is interrupted or terminated in a cable distribution head [35]. This is a cast-iron box, octagonal in shape, fixed on a side wall of the manhole, and with eight holes for the insertion of gunmetal unions. Through one of these the cable is led, the lead tube of the cable being connected to the gunmetal by a "wiped" joint. From the other holes other cables are led away. Those to the distribution pipes are usually 7-pair cables, of half-inch diameter. One lining

accommodates eighteen 7-pair cables, so that a 217-pair cable can be distributed through two such linings. The further subdivision of the 7-pair cable is effected by *double solid* and *single solid* joints, referred to later.

Main Cabling. The drawing-in of the cables is known as *cabling*. In the case of main routes it is first necessary to *rod* the pipes. Sweeps' rods with patent trigger joints, which prevent unscrewing in the pipes, are jointed length by length and pushed through the ducts. They are then used to pull through (*a*) a spun yarn mop, (*b*) a circular brush, (*c*) a test piece of cable one yard in length, and (*d*) a 3-in. rope. *a* and *b* are used to clean the duct, *c* is examined to see if any obstruction may be anticipated, and *d* is to be used for drawing in the cable. The cable, which is mounted on a big wooden drum, may weigh from two to three tons, and is brought to the manhole on a low float. To enable the drum to be revolved a steel axle is passed through its centre, and it is elevated on a pair of screw jacks. At the other manhole a winch has meanwhile been got into position, and the pulley rope brought round a pulley block anchored so as to be opposite the proper duct when the strain is applied. When all is in readiness four men turn the winch handles and the cable is fed in, turning off the drum and through a large arc of a circle into the duct. A liberal dressing of petroleum jelly is applied in order to facilitate its progress.



35. DISTRIBUTING BOX FOR 217-PAIR CABLE

Seven-pair Cabling. Similar operations, but on a smaller scale, are carried out in connection with the distribution cables. There is, however, one special feature which in London has been extremely valuable. Seven-pair cables can be introduced into pipes as required, the rods being introduced over the cables already in place. When the pipe is nearly full the ordinary 1-in. rods cannot be used, and a ½-in. steel-core rod is employed. Sometimes in long lengths it is desirable to use a few lengths of ½-in. rod, and then, to obtain the necessary rigidity, a special reducing length is used to connect on the ordinary 1-in. rods. In this way as many as 20 7-pair cables can be placed in a 3-in. pipe, and in cases where the distance between boxes is small, 23 can be inserted.

Cable Jointing. Proceeding from the less to the greater, we will first describe the making of a joint between two lengths of 7-pair cable. The materials required are a lead sleeve 6 in. by ½ in., 14 small paper sleeves for covering the conductor joints, some solder, some mixed resin and Russian tallow, lamp cotton, thread, and wrapping paper. Everything must be kept properly clean and dry, and to this end a Gothic tent is usually mounted over the joint box. The paper sleeves and wrapping paper are kept warm over a spirit lamp. The lead sleeve is threaded on to one of the cables.

From each cable end a 6-in. length of lead is removed, exposing the outer paper wrapping, which is cut off back to the lead. The seven pairs of wires, each with its identifying coloured thread, are separated; in each case the thread being carefully looped round its proper pair. The arrangements for identification are so complete that when the jointing has been done properly, a cable can be cut into at any point and any required wire picked out. To achieve this the two wires forming a pair are wrapped one in red and one in white paper; these are the A and B wires respectively of the telephone pair. Round the centre pair of wires there is a white thread. This is No. 1 of the seven pairs. No. 2 has a black thread, No. 3 blue, No. 4 green, No. 5 two threads, one red and one black, No. 6 red and blue, and No. 7 red and green. Without unrolling the paper the whites of No. 1 pair are laid across each other at a point 1½ in. from the ends, the white thread from one side being included. A few twists are made, and then the remainder of the paper is stripped off and the copper conductors twisted together for a length of an inch. The twisted joint is then laid parallel with the wires, and a paper sleeve, which has previously been threaded on to one side, is brought over the copper joint. The other pairs are similarly treated, an expert jointer arranging that the joints are "staggered" so as to reduce the maximum diameter.

A wrapping of paper is then put over all and tied down tightly with thread. The lead sleeve is now pulled over the conductors and set up vertically so that one end may be soldered. A little wad of lamp cotton is first pushed in between the cable and the sleeve, some tallow and resin comes above this, and by means of a small spirit blow lamp the opening is neatly closed with solder. The other side is similarly dealt with. It should be stated that before making such a joint the lengths of cable are adjusted so that when completed the cable joint may be neatly trained round the box and fastened up along the side on a supporting bracket. Single solid joints are used to connect a 7-pair cable to seven separate 1-pair cables. A special sleeve and a solid lead plug containing seven lengths of 1-pair cable are used. The method of jointing is similar to that described above, with the addition that the conductors are tipped with solder at the joint and that melted insulating compound is run into the sleeve, which is provided with a screw cap inlet. Double solid plugs connected by seven lengths of 1-pair cable are provided for connecting 1-pair cables to 7-pair cables at intermediate points.

Cable Codes. To facilitate reference and identification every cable has code letters allotted to it. Junction cables have four letters; main distribution cables, three letters; and 7-pair cables bear the three-letter code of the main cable they spring from, plus one or more letters. Thus, the circuits on Nos. 1 to 7 in main cable QBX become in the 7-pair cable QBX+A, Nos. 8 to 14 are in QBX+B, and so on round the alphabet.

The connecting up of subscribers takes place from the box outwards, and in a properly managed system plans are kept up to date, showing the position of every wire both working and spare, and new subscribers are added without the slightest disturbance to those in existing cables, everything being planned out in the drawing office and complete detailed instructions issued to the workmen.

TELEPHONES *concluded; followed by* ELECTRIC CABLES

Group 3
PHILOSOPHY
2

Continued from page 6259

IS THE WORLD REAL?

The Failure of Materialism to Explain Life. How Prof. Hæckel's Foundations Slipped Away. Is Mind Matter or Matter Mind? Idealism and the Problem

By Dr. C. W. SALEEBY

THE word "monism" is derived from the Greek *monos*, one, and therefore literally means simply one-ism.

Now it is, of course, evident that the word as such makes no assertion as to the nature of the one; it merely crystallises in a modern term the idea expressed in Indian philosophy thousands of years ago that "the Real is one." The word, however, has somewhat ingeniously been appropriated by those who believe not merely that the Real is one, but that this one is essentially physical and not psychical. Armed with this word, they are in the habit of describing all their opponents as "dualists" or "pluralists"—persons who believe that the real is not one, but two or many. This is, of course, a quite unwarrantable assumption.

Monism is Oneism. The truth, indeed, is that all honest and serious thinkers of all ages have admitted the monistic principle—have indeed been monists. The demand for some unifying principle is an imperative necessity of the mind of man directly he begins to think. In his heart of hearts every thinker believes that the Real is one, and this central principle of what now calls itself monism, so far from being in any sense new, is quite the oldest doctrine in philosophy. Indeed, we may safely say that there could be no philosophy until the human mind had advanced far enough to entertain this very idea. Properly speaking, then, when we use the word "monism" we should always employ a qualifying adjective. The monism which has succeeded the materialism of last century should properly be called materialistic or physical monism. Beside it, for the sake of order, we may place in our minds two other kinds of monism which have absolutely equal claims to the use of that word. One is *pantheistic monism*, which asserts that everything is God. This great conception is the central tenet of what has lately been called the "new theology," and is probably about three thousand years old. Lastly, there is *idealistic monism*, or idealism, which asserts that everything is mind. To those who especially call themselves monists to-day pantheism is pure superstition, and idealism is pure nonsense.

A Ridiculous Riddle. The supporters of these doctrines have every whit as good a title to the use of the word "monism." We have yet to hear more of it, of course; meanwhile, let us note that the battle has always been, and still is, not between monism and pluralism—for no one believes that the Real is many—but between monism and dualism, the doctrine which asserts that the real is two, what we call mind and what we call matter. Our business, then, in tracing the materialistic school of philosophy, is to address ourselves to that particular doctrine to which, of late, the great name of "monism" has been especially attached.

This new doctrine is the legitimate successor of the materialism of last century. It is the doctrine that everything that exists is really a form of what the physicists call "energy," and plainly the best and simplest and most accurate title for it would be *energism*. This new doctrine is at present in need of a proper philosophic statement, and so we ourselves must do our best to fill the gap. The nearest approach to such a statement will be found in Professor Hæckel's "Riddle of the Universe." That volume, recent though it is, already contains a great deal of very ludicrous reading, and if there be any competent person who believes in the philosophy which it contains, he is really called upon to provide a successor to that book, less easily contradicted by the admitted facts of physical science. It is in the absence of any such successor that we are compelled, curiously enough, to outline the newest form of this doctrine without having any author to whom to refer.

The Lost Foundations of Professor Hæckel. Omitting any inquiry into the nature and conditions of our knowledge, and taking it for granted that the crude realism of common-sense is open to no question, Hæckel turns to the physical sciences for foundations upon which to build. For this purpose he takes from physics the law of the conservation of energy and from chemistry the law of the conservation of matter, and upon these as co-equal and co-relative, he builds. Nowadays, however, chemists have been compelled to abandon utterly the law of the conservation of matter, as we have seen in another course, and with the disappearance of matter as in any sense an entity Hæckel's pages can no longer be regarded as relevant to the philosophic problem as it presents itself to the mind of the twentieth century. The following is a recent and very acute criticism of Hæckel's position:

"He believes that mind and soul are inherent attributes of all bodies. Curiously enough, he supposes that by making mind a universal attribute of matter he has made his philosophy not materialism, but monism. It is really both: monistic, because it reduces substance to one kind; materialistic, because it identifies that one kind of substance with body or matter, and reduces mind to an attribute of matter. It makes no difference to attribute mind to all matter, so long as it is attributed as an attribute. It is at least as materialistic to say that unconscious mind is an attribute of brain; and this is the position of Hæckel." [Encyclopædia Britannica. Tenth Edition. Article on "Metaphysics."]

But, as the reader is surely aware, this word "matter," which fills so large a place in the pages of Haeckel and his predecessors—and also, indeed, in the pages of philosophy generally—has lately suffered many strange experiences, and the upshot of them is no less than that the word "matter" has henceforth no reason or business to occur at all in any philosophic controversy. We are compelled to believe, nowadays, that matter is merely a more or less transient manifestation of that wider something which physicists now know as energy, and the really important and vital thing is the new aspect which the old doctrine bears when it has been restated, as it must be.

The Sad Betrayal of Materialism. From the very first, materialism has had a magnificent advantage over all other philosophic systems. As the mind of man is constituted, there is nothing that breeds such conviction in it as the palpable and the tangible. The abstract, the invisible, the impalpable, is for most minds more or less of a fiction. It does not "really" exist in the sense that a marble or a grain of sand exists. There, at any rate, is something which you can touch, something that you can feel the very resistance of. It is real. Now, materialism is simply the doctrine which asserts, or used to assert, that this good, hard, palpable, tangible stuff which we call matter is the real real. It asks us to conceive, as we think we can so readily conceive, of everything in terms of tiny bricks or grains of sand moving about in one direction or another. The picture is simple and intelligible, and it makes an appeal to that particular sense which, humble though it really be, has the privilege of endowing its information with a peculiar certainty—the sense of touch.

Now the real value of the recent scientific study of matter lies in the curious transformation it has wrought in the plausibility of materialism. That poor doctrine has been cruelly betrayed in the house of its friend. Uncritically examined, the conclusions of science seemed not so long ago to afford some sort of surface ground, at any rate, for this doctrine, which declares in effect that atoms are the only real thing and that mind is a myth. Upon that imperfect scientific conception materialism was built—any inquiry as to the nature of our knowledge of atoms being ignored.

Materialism a Philosophy Without Foundations. But now, quite apart from any criticism of knowledge, materialism finds itself in the difficulty of feeling its very foundations slip from under it—not into nothing, but into the intangible. There is, of course, something to which atoms correspond, something of which they are a manifestation; but that something is intangible, and there's the rub for materialism. Its age-long advantage of appealing to the sense of touch, in which we are apt to believe so heartily, has been taken away. However real a marble may feel to us, that peculiar sense of reality can no longer be appealed to or utilised by the materialist. His theory is now on a level with other theories, and can make no special appeal to this biassed judge. For the marble, despite its convincing air of solidity, must yet be conceived by us, if we are to accept the verdict of science at all—as materialism constantly asserts that we must—in terms not of hard atoms as resistant as itself, but in terms of electrons which, we are now taught, have no mass that is not electrical inertia. Now, materialism, as it has lasted throughout the ages, has really been built upon this notion of mass. There, at any rate, in whatever had stuff in it—good massy, solid stuff in it—there, at any rate, was something real; but it is rather a different task to persuade mankind that the only ultimate reality is electrical inertia.

The Real is Unknowable. But let us give the doctrine a fair chance, and employ a word which is more familiar, and which, at first sight, we may seem more easily to grasp. It is to the something called "energy" that physical science would now reduce the external world. All matter has to be regarded as simply a mode of energy, and we have to try and conceive of this something as the only physical reality. We may remark in passing that this physical conclusion is by no means as secure as some would have us suppose. There is, for instance, the little problem of the universal ether, about which no one has yet said anything that he can persuade anyone else to believe. But still, we may take it, for the sake of argument, that all external things are simply transient modes of this one thing—energy, and we may then address ourselves to the very necessary question, What is energy *itself*?

The plain fact is that we cannot get any "clear and distinct notion," as Descartes would say, of the nature or inmost reality of energy. We know of it nothing but what it accomplishes; it is a something that has power, and this power seems to be incapable of creation or destruction; but in what it inheres, what is the *substance* of it? These questions we cannot answer at all. This is a strange conclusion to be reached in the order of time by those simple, dogmatic, and so plausible propositions which materialism with its hard, round, massy atoms, used to afford us. All criticism of the nature and quality of our knowledge apart, we are now ordered to brush aside tangible matter as a mere transient accident, and to endeavour to conceive what is indeed utterly beyond conception. The inner nature of the external world we find to be unknowable, inconceivable, ineffable.

And the most significant thing is this—that our conclusions are not based upon "metaphysical" considerations; we are not forced to them in deference to the criticism of professional philosophers, nor psychologists, nor logicians. On the contrary, they are the conclusions directly reached by physicists as a direct consequence of their continuance in those very studies upon the immature stages of which the old materialism was built.

What is Mind? But there is now growing out of modern physics a new and very plausible theory which constitutes a further attack upon the supremacy of mind, and which seeks to clinch once and for all the case for energism. The older materialism did not attempt to include mind within its system. Mind was simply an accident that could be ignored; it had

a physical basis and origin, but it could not be thought of as having any real existence at all; not even a physical existence. Remembering that the older materialism was based upon the idea of atoms, we can understand how it was that no one ventured actually to count mind amongst the material things. The old speculation of Democritus, which made the mind consist of a particular kind of atom, was evidently too naïve for modern use. But the reader will readily understand that, just as the new form of materialism loses in plausibility by no longer having the tangible atom to appeal to, so it greatly gains in plausibility in another direction, for it finds possible the argument that this impalpable, inaccessible, but nevertheless physical something, which is called energy, may display mind as one of its forms.

Is "Mental Energy" Physical? We all speak at times of mental energy—a somewhat vague phrase, which nevertheless stands for an intelligible idea; and the passage is easy from regarding this phrase as a metaphor to regarding it as the literal truth. Electrical energy, kinetic energy, thermal energy—why not mental energy? Everything except mind has been more or less clearly resolved into what the physicists call energy. This is capable of infinite transformation—sometimes into gross forms, such as ponderable matter; sometimes into utterly impalpable forms, such as chemical energy and other forms of potential energy or energy of position. Now, we know that mind is intimately correlated with physical energy, for we know its correlation with the brain, which, physically considered, is only a gross manifestation of physical energy. Why, then, should not mind be one of the subtler modes in which physical energy may display itself?

Up to a point, the argument becomes more powerful the more it is studied. If we approach it systematically from the inorganic to the organic we find that the problem of life itself affords what seems to be a convenient link, hinting at the real identity of physical energy and psychical energy. The more complete is our study of the physical sciences, the more thoroughly we blend physics, chemistry, and biology into a consistent and coherent body of knowledge, the more strongly are we convinced that this something which we call energy is the one universal reality, uncreateable, indestructible.

Is Mind a Form of Matter? Thus convinced and strongly urged to the view that the Real is One, the student proceeds to consider *mind.* We can readily understand how it seems to him, thus prepared, to be almost a necessary truth that, just as motion, sound, light, heat, electricity, magnetism, the chemical forces, the vital forces, were found each in turn to be forms of energy, so, of course, this next entity that he has come to study is just another form of energy—a form somewhat more subtle, perhaps, somewhat more ethereal, somewhat further removed from matter, which may be conceived as the grossest form of energy, but, nevertheless, necessary to be identified with all, these in the last analysis. Space is too precious for us to repeat anything already said on page 2115, but the argument is so important, and especially so important to-day in the absence of refutation of it from the scientific side, that we must add something to what has there been said. The following considerations are new, and the reader is asked to study them in association with the page referred to.

The Physical and Psychical. It is a wholly gratuitous assumption, and is doubtless untrue, that in the course of an hour's consciousness the brains of two men consume equal amounts of food material. But let us grant it for the sake of argument. The facts are these. If you oxidise a gramme of phosphorus, whether in a brain or in a test-tube, you will obtain the same amount of heat. Meanwhile, however, one such brain is yielding, in addition to the heat, Macbeth's speech beginning: "To-morrow and to-morrow and to-morrow." Another such brain is producing imbecile doggerel; and the test-tube is producing nothing besides the heat. Those who maintain that mind is a form of energy have it incumbent upon them to demonstrate the strict quantitative equality of (1) Macbeth's speech; (2) imbecile doggerel; and (3) nothing.

In truth, there is no quantitative relation between the psychical activities and the physical activities of the brain. The present writer has yet to meet with any recognition of the philosophic significance of a fact well known to dieticians, that there is no correlation between mental work and the amount of food required. It is recorded by Professor Atwater, one of the most distinguished American students of dietetics, that "a man was confined in a respiration calorimeter for a number of days, and on certain of them he engaged in the severe mental work of reading a German treatise on physics." The subject purposely worked very hard at the book, since he well understood what it was desired to ascertain by the experiment. All the other conditions were kept carefully constant, but it was found that *on the working days the bodily waste was no greater than on the days when no mental work was done at all.* All the exact experiments that have been made agree that mental work, whether productive or receptive, has no quantitative relation whatever to the transformation of physical energy.

Eating and Thinking. This absolute want of any quantitative relation between psychical and physical energy is of significance not only because such a relation must be demonstrated before any physical theory of mind becomes plausible; it is of practical interest in relation to dietetics. If we consider the effortlessness of the highest genius, and the frequent sparseness of diet of intellectual workers of the highest order, we find it impossible to doubt that the most potent and complex psychical activities may be correlated in one brain with the oxidation of much less food material—that is to say, with the transformation of much less physical energy—than may be required by another brain, the psychical activities correlated with which signify nothing. It is very commonly observed that men of consummate genius have been sparse eaters.

Amongst recent instances are three great figures of the nineteenth century, Darwin, Huxley, and Spencer, all of whom suffered from chronic dyspepsia. For many years Spencer's diet cannot have been more than one-fourth or one-fifth part of the ordinary diet of a man of his weight. Yet his psychical activity was incessant, and since it kept him awake he was ever at a loss for fresh devices to make him "stop thinking." If we follow the argument out, and consider the case of the large eater, in whose body enormous quantities of physical energy daily undergo transformation, we shall see some meaning in the idea to which men in all ages have given utterance—the idea of the burden of the physical, and the load it imposes upon the psychical.

"When We Lie A-thinking." On the popular theory that mind is a form of physical energy, any such doctrine of the burden of the physical spells nonsense, for in proportion as mind is exhibited, its source—physical energy—must be supplied to the body. The facts, however, are notoriously otherwise, and, on the contrary, lend a somewhat novel support to the ascetic principle—the principle that the bodily or the physical must be kept under, lest it burden and clog too much the psychical. There is a fallacious reply to this argument which depends upon the confusion of physical with mental energy in the case of the individual man. Many men of action are, and have been, men of great physical energy. In the course of their enterprises they will actually utilise an amount of physical energy which is exceedingly large, and such men must inevitably be hearty eaters; but it is an utter confusion to confound this energy of the energetic man—which is obviously and measurably physical energy—with the psychical activity of pure thought. So far as all evidence and probability goes, there is absolutely no quantitative relation between the psychical and the physical when one lies a-thinking in the night. Physical changes are, of course, occurring in the brain, food material is being broken down, and potential chemical energy is being transformed into kinetic energy, such as energy of heat. But a complete equation could be written, demonstrating the truth of the law of the conservation of energy, *without the insertion on either side of it of any psychical term;* and, as we have already observed, if it were attempted to insert any such psychical term there is no conceivable unit of quantity which could be employed in the statement.

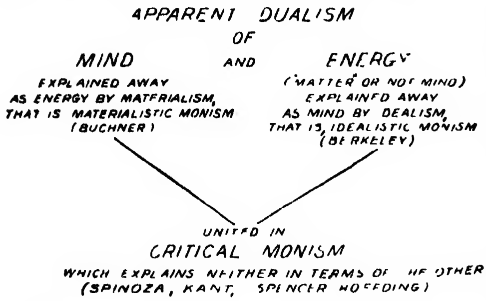
Mind and Not-Mind. We pass on to a new subject, and meanwhile let us take stock of our position. We have attempted a complete refutation of the doctrine that mind can be included within the physical, which latter, by general consent, has been reduced to a somewhat intangible One. Now, that seems to be something accomplished; but observe that our rejection of materialism or energism seems to involve the loss of our belief that the Real is One. We find ourselves asserting that the Real is not One, but two—mind and not-mind. We find ourselves rejecting monism—which is the goal sought by every philosopher—and accepting a dualism. We have yet to see whether this dualism is proximate or ultimate. Here, at least, we may note the historical fact that the greatest thinkers of the past have never yet rested content with this dualism of mind and not-mind—or mind and matter, as men used to say—as the final truth. On the contrary, they have always gone on to seek behind or within this proximate dualism an ultimate oneness or monism. To this we must return.

The Opposed Schools of Materialism and Idealism. Meanwhile, however, let us pursue our systematic course. In the face of this apparent dualism between mind and not-mind, two ever opposed schools of thought have sought two diametrically opposed solutions which at least agree in this, that they seek alike to dethrone one of the terms of the dualism and to explain it in terms of the other. Materialism in all its forms declares that the dualism is only apparent, since not-mind is the reality and mind may be explained in terms of it. That view we have discussed. Over against it, throughout the ages, another school of philosophers have placed the precisely opposite view. They also have sought to dethrone one of the terms of the dualism and to explain it in terms of the other. But it has seemed to them that it is not-mind which must be dethroned and explained in terms of mind. "The only reality is not-mind," says materialism; "the only reality is mind," says idealism.

Now, we are studying what is incomparably the most difficult subject to which the human mind can address itself, and we shall reach no goal at all if we do not take frequent bearings. For this purpose the writer has attempted to prepare a scheme which may be of some use. In it we shall definitely abandon the word matter, and we shall accept the great physical generalisation which includes, or attempts to include, under the unitary fact called energy everything that is not-mind.

A Third System of Thought. We contemplate, then, an apparent dualism of mind, on the one hand, and energy on the other, this last word being used in its technical scientific sense. We then proceed to discuss two great systems of thought which have one point and one only in agreement. This is, that one or other of these two terms, mind and energy, is *the* ultimate. Materialism attempts to describe mind as energy; idealism attempts to describe energy—that is, the external world—as mind or mental creation. It is incessantly asserted by thinkers of both these schools that there is no third choice—except to rest content with dualism, as no one can. Let us have it clearly stated, however, before we proceed to discuss idealism, that there *is* a third choice. This consists in examining afresh the two terms in our apparent dualism, and seeking a monistic solution, not by the sinking of the first in the second, nor the second in the first, but by rejecting both alike as ultimates, and by regarding them as the converse aspects of a *something beyond*, which is their common *substance*. Following Professor Höffding, we may call this third doctrine *critical monism*, since it is a monism based upon a criticism of our knowledge of mind on the one hand, and our

knowledge of energy on the other hand. Critical monism asserts that the idealists have not criticised their notion of mind, and that the materialists have not criticised their notion of energy. Here is the scheme, which may possibly crystallise what would otherwise be chaotic. Having thus seen the direction in which we are going, let us attempt to do justice to the great system of thought which is called idealism.



The Master Idealist. Many names of various greatness may be associated with idealism. The greatest of them all, George Berkeley, Bishop of Cloyne, was born in Ireland in 1684, and died in Oxford in 1753. Though he lived almost all his life in Ireland, he was an Englishman. He was not only one of the most illustrious philosophic thinkers of all time, not only by reason of his "New Theory of Vision" a master in science, but also one of the noblest and most beautiful characters of whom history has any record. Says one critical and cold-blooded contemporary, "So much learning, so much knowledge, so much innocence, and such humility, I did not think had been the portion of any but angels till I saw this gentleman." His wonderful book on "Optics" was published when he was twenty-five, and his "Principles of Human Knowledge"—one of the few greatest works of all times—when he was twenty-six. In some remote age, when "oblivion has spread her poppy" over the memory of the statesmen, falsely so-called, the warriors, the self-seekers, and the crowned fools and knaves whose ignoble names fill our history books and are thrust in all their pettiness into the memories of our children, the name of Bishop Berkeley will be remembered and honoured at its due worth.

Idealism and Common-sense. Now, let us enter into a preliminary warning before we proceed to discuss the philosophy of Berkeley. Pope has a line, "And coxcombs vanquish Berkeley with a grin." His views have been "laughed at, written at, taught at, shrieked at." Everyone is familiar with the story of Dr. Johnson, that incarnation of the limitations of common-sense, who thought he had disposed of Berkeley by kicking a stone. Let us try to recognise what every student of philosophy must know from his own experience—that there is a stage of mental development in which idealism appears to be the most monstrous of absurdities. Some of us may remember hearing at school the quaint notion that the world only exists in our minds or in some Higher Mind than ours; and probably, after the fashion of schoolboys, we characterised this notion as "rot." Now recent psychology has shown that a very large proportion of the population never develop at all beyond the stage which may conveniently be described as the twelve-year old mind, and to the twelve-year-old mind, certainly, the doctrine of idealism is the sheerest nonsense—"only that and nothing more." Whatever our conclusions may finally be, let us remember the great advice of Lord Acton—"to understand what we reject as thoroughly as what we accept."

Idealism and Matter. When we say that Berkeley denied the existence of matter—or, as he would now have to say, physical energy—we do not mean that he denied, or acted as if he denied, the phenomenal existence of phenomena. The difference between him and his opponents is that, while they postulate something behind phenomena, Berkeley says that this supposition is superfluous. He finds no need to suppose that there is an inaccessible *noumenon* or substance underneath all the properties by which we know the outside world. For him those properties are themselves the whole thing. There is nothing beyond the world of sense, *but*—this world of sense is no more than the phrase suggests—a world of *sense. Outside and beyond sense it has no existence.*

What we commonly do, however, is to group together in our minds certain of the properties or qualities from which we infer the external world, and then we declare that these inhere in something which we agree to call matter, or nowadays energy. According to Berkeley this is a creation of our minds, and has no existence outside them. It is our minds that have put together these qualities and properties, compared them, and then explained them in terms of something behind. But there is no such something behind; it is only our way of thinking. As Berkeley points out, once we admit its existence we find ourselves in all sorts of difficulties. The further we pursue it the more certainly we find ourselves in absurdities and contradictions; but, says Berkeley, "Upon the whole, I am inclined to think that the far greater part, if not all, the difficulties which have hitherto amused philosophers and blocked up the way to knowledge are entirely owing to themselves — that we have first raised a dust, and then complain that we cannot see." He boldly solves the difficulties in which realism finds itself, and especially the pre-eminent difficulty of explaining how it is that mind can know not-mind at all.

The Doctrine of Berkeley. Here is the famous passage in which, especially in its last sentence, his theory is stated: "That neither our thoughts, nor passions, nor the ideas formed by our imagination, exist without the mind is what everybody will allow; and to me it is no less evident that the various sensations or ideas imprinted on the sense, however blended or combined together, cannot exist otherwise than in a mind perceiving them. . . . The table I write on, I say, exists—*i.e.*, I see it and feel it—and if I were out of my study I should say it existed, meaning thereby that if I

was in my study I might perceive it, or that some other spirit actually *does* perceive it. As to what is said about the existence of unthinking things, without any relation to their being perceived, that is to me perfectly unintelligible. Their *esse* is *percipi*; nor is it possible they should have any existence out of the minds or thinking things which perceive them."

If we perceive nothing but our own ideas and sensations—which everyone admits—it is impossible to imagine that any one of these ideas, or any combination of them should exist *unperceived.* Their *esse* is *percipi*—their being is the being perceived. Furthermore, "When we do our utmost to conceive the existence of external bodies, we are all the while only contemplating our own ideas."

Followed out in its logical entirety, this theory leads Berkeley to the famous passage which it is a privilege to quote:

"In a word, all the choir of heaven and furniture of earth—all those bodies which compose the mighty frame of the world—have not any subsistence without a mind; their *esse* is to be perceived or known, and consequently, so long as they are not actually perceived by me, or do not exist in my mind, or that of any other created spirit, they must either have no existence at all, or else subsist *in the mind of some eternal spirit.* . . ."

The Crux of Idealism. The most obvious retort to the idealist, of course, is the question whether he believes that the round earth, and all that it contains, would vanish with his annihilation, and the reply he must make is that of Berkeley himself: "Whenever bodies are said to have no existence without the mind, I would not be understood to mean this or that particular mind, but all minds whatsoever." Then it might be replied that the whole human race may conceivably suffer destruction: would this involve the annihilation of the external world? Berkeley's doctrine, however, does not lead to the conclusion that the existence of dead matter depends upon the existence of living matter.

But now for a further objection to idealism—an objection which every consistent idealist recognises and which it seems impossible to answer. Let us freely grant Berkeley's position as regards the external world in general. But how does the idealist escape from the conclusion that he, as a perceiving entity, is the only thing that exists at all; that he is not merely the centre of his own universe, but *is* the whole universe—that is to say, that apart from him all other things, including his fellow men, have no being? Here and there a stray thinker has been found who thought himself compelled to accept this conclusion, which is sometimes known as *solipsism*, but evidently it is too monstrous for anything but ridicule. If idealism necessarily leads to the conclusion that he, the idealist, is *solus* and *totus*—alone, and the whole—then so much the worse for idealism. And, in any case, if he thinks so, why does he make a fool of himself by saying so, there being none to hear?

The Supreme Idea of the Divine Mind. Now we need not imagine anything so foolish as that so obvious a criticism as this did not present itself to the magnificent mind of Berkeley. His answer to it we may readily anticipate. It is that he and other men "subsist in the mind of some eternal spirit." Without this supreme idea of the divine mind, idealism cannot hope to stand at all. It might effectively criticise all other philosophies and reduce us to scepticism, but it could substitute nothing for them. None of us has any use for a doctrine which asserts that his best friend has no existence outside his own mind. This is the last and most ridiculous egoism.

But, completed as idealism may be by invocation of an all-embracing divine mind, in order to solve what would otherwise be insoluble difficulties—so completed, it may be incapable of rational proof, but it is equally insusceptible to the assaults of rational criticism. It is a consistent, self-consistent, complete, and noble hypothesis.

The Grandeur of Idealism. Starting with the one fact of which we are absolutely certain—the fact of the existence of spirit, mind, or something that thinks—it proceeds by processes of impeccable logic until it has constructed what is not only a great philosophy—whether or not it actually compels rational assent—but also the basis of a mighty religious conception. Technically and rationally, this idea of the divine mind is perhaps an assumption; it may be declared to be outside the proper range of philosophy—that we have no right either to assert or to deny regarding it. That is a question which it is impossible to follow up here. Berkeley would say that it is a necessary assumption, and that without it we find ourselves in greater difficulties—that is to say, rational difficulties—than with it. But this we may recall or anticipate—that the conception of a universal mind is by no means a last resort for puzzled idealism, by no means merely a *deus ex machinâ.* On the contrary, some such conclusion is reached by many other roads, and with what compels us to regard it as equal necessity.

Since the time of Plato, at least, there have been idealist philosophers, but it is frankly to be confessed that they feed the mind on very little more than wind and words. After you have long tried to get hold of them, and failed, you begin to suspect that there is really nothing there to grasp. When it is found, also, that they incessantly contradict themselves, that none of them has any difficulty in refuting all the others, that the disciples of their bosoms offer wholly contradictory accounts of what the master taught—your conviction is reasonably confirmed.

"We Live in the Creation." It is really unnecessary to discuss these other idealists at any length, though just the very briefest mention must be made of the name of Hegel (1770-1831), who founded a school—if school it can be called—which was dominant for many years in his native Germany, was exported to Oxford, and is only now beginning to evaporate there. Hegelianism is founded upon the doctrine that "to be and not to be are the same," and that the non-existence or the nothing *exists,* because

it is a thought. Thus beginning with the *identity of contraries*—the principle that everything is and at the same time and in the same sense is not—it may well be imagined that Hegelianism ends in the most amazing medley of verbal absurdities that the human mind has yet achieved.

At least, however, we cannot leave the name of Hegel without commenting upon the magnificent advance involved in his idea of creation. To Hegel, as indeed to many greater thinkers than he (but his statement of it was of historical importance) the "creation of the world" was not a thing once done by God, but a thing perpetually doing by Him "in whom we live and move and have our being." Creation is "God passing into activity; but neither suspended nor exhausted in the act." God did not make the world "one fine day," nor in seven, but sustains and creates and recreates it "from everlasting to everlasting."

The Newest of all Philosophies. Now, it is to be hoped that we have not lost our bearings. Let the reader glance again at the scheme which we made for him. We have discussed as best we may the two fundamentally opposed doctrines of materialism and idealism, and we have noted also the one point in which they agree. We must pass on now to the philosophy of the present day. Doubtless that embraces thinkers of many schools, but still it is fair to say that the systems which we have been discussing are scarcely representative of current philosophy, which has been so deeply affected by the criticism that was the chief part of the life work of Kant.

It is not necessary here to return to the philosophy of Kant, the substance of which we have previously endeavoured to state, but we may trace in the present day, and to him, the wide recognition of the necessity of examining even our most cherished notions before we venture to build great philosophic generalisations upon them. This demand that we shall beg no questions at all —and least of all the question, What is truth?—has generated in the present day, in England and America, what is indeed the very latest brand of philosophy; and before we pass on to greater themes we must spare a word for this new school, especially as its case is very interesting, and has lately become very popular.

What is Truth? The chief names that may be mentioned in connection with this most up-to-date of philosophies are those of Professor Dewey and Professor William James, of America, and Mr. Schiller, of Oxford. It is from the latter especially that we draw, as accurately as may be, the argument of this new school regarding the agelong and fundamental question, What is truth?

We must say, in a word, that according to this school we have no means of knowing or identifying the truth except in so far as we may agree to call the truth anything that "works." The name which has been given to this new philosophy is "pragmatism," from the Greek verb *prasso* (I work, accomplish, or achieve), and it is upon this conception that the philosophy is built. Its importance for us at this point lies in its rank as a critical philosophy, and its criticism is certainly directed to the very root of the matter.

An Old Test of Truth. Many are the thinkers who have addressed themselves to this question of the means by which we may identify truth. Probably on the whole this is the first preliminary question of all philosophy, for, if we are not agreed as to the answer, or if no answer is obtainable, it would seem hopeless to proceed further. The essence of the pragmatist position consists in examining and rejecting various tests which have been proposed for truth and substituting a new one.

It is not necessary here to examine the various ways in which truth has been defined, nor to discuss the issue between the absolute scepticism which denies that we can know any truth and the relative scepticism which declares that our knowledge, even if it be only symbolic, is yet valid so far as it goes. Suffice it that, by practically general consent in these days, philosophers are agreed that the test of truth is precisely that which each and all of us employs as the test of truth in daily life. It is *consistency with the rest of experience*. This is not to assert that the test is a final one or that it never errs. Obviously its value must depend upon the quality of the rest of experience. The immobility of the earth was for ages regarded as a truth just because all experience seemed to be consistent with it, and with nothing else. Yet with the widening of experience and the making of astronomical observations, which added new *data* to experience, the theory of the motion of the earth came to be the only one now consistent with the rest of experience, and it is accepted on that ground.

A New Test of Truth. Let the reader take this idea with him into his thoughts and life for a few days, and he will realise that it is by this means that we all of us judge of truth or fact. Let him reflect further that all human action and thought furnishes evidence of the value of this principle, and let him also ask what is assumed by everyone who uses it. The assumption that no fact can contradict, but on the contrary must be consistent with, any other fact involves the belief that the universe is a universe, and not a chaos. Though, like the rest of mankind, they use this test in their daily lives, pragmatists endeavour to show that it cannot at all be accepted as a test for truth. Instances such as that of the motion of the earth, however, in no way affect the validity of the principle. They merely show the results of its imperfect application. However, it is possible with a little skilful writing to make this test of truth, its consistency, seem absurd, though, of course, you are assuming its value in every word you write, and would be very much astonished if your readers took your argument to be a comic story about a dog and a tin kettle. Thereafter the pragmatists set up a new test of truth, as interesting and attractive as may be. This test is to be nothing else than human action. There is and can be no truth, say the pragmatists, except just what suits him who believes it. If it suits him, serves his life, and goes with his actions, then he may know it to be true—nor can he do so by any other means.

Continued

WHAT TO DO IN ACCIDENTS

How to act in Cases of Emergency. Treatment of Wounds and Bruises. How to Restore Respiration in Cases of Drowning

By Dr. A. T. SCHOFIELD

WHEN an accident occurs, let the patient lie or sit. If he is at all faint or insensible, keep him lying down flat, loosen the things round his neck, and do not let people crowd around, but keep them away so as to give him plenty of air.

Do not move him at all till you quite understand his injury, and be as quick as possible in finding out what is wrong.

Until the patient is removed to his home, or to a suitable place, let your aim be only to stop any bleeding for the time, and to prevent injury in moving.

Avoid needless questions and pulling about. Unless the case be plainly trivial, send for a doctor at once. Do not *drag* clothes off an injured part, but carefully rip them up or cut them off to examine it. When you have to remove the clothes, take them off the injured side last. Always begin on the sound side.

If the patient appears very low, give two teaspoonfuls of brandy, or a little water with a few drops of sal volatile.

Hæmorrhage Cases. We will now consider the most common emergencies one by one. In hæmorrhage, if the blood be bluish and dark, it is from a vein; if bright red, and comes in spurts, it is from an artery. The latter is far more profuse and dangerous than the former. In all cases one must act decidedly and quickly.

The first thing is to see where the blood is really coming from, and at once to fold up a bit of rag, handkerchief, or any other cloth, and press on the spot with your thumb steadily until you can get a bandage ready.

Pressure on the spot where the blood comes from is always the first thing to aim at. Do not stand and look at it, but make at once a determined effort to stop it.

In most cases, in a minute or two the blood will cease to flow, and will clot. The pressure must not be taken off, but another neat pad must be made by folding up a piece of rag, and then placed over the first, and a bandage put round the part.

If, however, the blood still flows round your thumb and from under the pad, look out for garters or tight strings above the wound, and cut them. Always raise the limb and expose the part freely to the air; by these means you lessen the flow of blood and make it clot more quickly. Should it continue to flow in jerks, at once press on the artery higher up than the place from which the blood comes.

If the blood comes from *the head*, firm pressure against the skull with a piece of cork in the pad is generally enough, if well secured.

If from *the face*, the blood-vessel should be held tight between one of the fingers (inside the mouth) and the thumb (outside).

If from *the neck*, as in cut throat, press the artery you feel beating below the cut firmly against the back of the neck.

If from *the arm*, press the artery above the wound with the fingers against the bone till the bleeding stops; or knot a handkerchief loosely round the limb, and then, with a stick, twist the handkerchief round and round till it squeezes the artery tight.

If from *the forearm*, press in the same way on the arm artery, or put a pad in front of the elbow, and bend the arm up firmly on it.

If from *the thigh*, press the artery in the centre of the groin firmly down with both thumbs on to the bone.

If from *the leg*, put a pad under the knee, and bend the leg forcibly on it.

An indiarubber band, tube, belt, or brace stretched firmly round the arm or leg above the wound stops the bleeding at once.

Bleeding may come on suddenly from the nose or mouth. If from the nose, and it is not excessive, it may relieve headache and congestion, and do good rather than harm. If, however, it continues and is severe, do not allow the person to hold his head over a basin, but make him sit up with his head erect, and hold his own nose firmly for five or ten minutes, while you slip a cold door-key down his back. This attitude and slight shock is often enough to stop it. Should bleeding continue, or blood run down the throat behind, soak a handkerchief in common turpentine and let the fumes be sniffed up. The arm raised above the head also stops it. It it still persists, send for the doctor without delay.

The blood may come from the mouth. If it comes in any quantity, its source is probably either the stomach or lungs.

If it is from the stomach it will be rather dark, mixed with food in large quantities, and vomited up after a severe pain. If from the lungs, it will be very light, mixed with froth; it will be coughed up, and come in lesser quantity.

In either case, lay the person down under an open window, loosen everything about his neck, keep him quite quiet; and to stop the bleeding—supposing the doctor is not at hand—give him a teaspoonful of turpentine in a little milk, and let him breathe in turpentine from a soaked handkerchief.

Bruises and Wounds. Bruises are injuries caused by falls or blows, which may result in internal lacerations, particularly of the smallest blood-vessels.

In slight cases, apply hot fomentations or spirit and water lotion to the bruise to prevent discoloration.

Wounds may be clean-cut, torn, bruised, stabbed, poisoned, or gunshot. They heal in two ways:

1. Quickly, by primary union (union by the first intention) without suppuration, leaving only a very fine scar. This mode of healing should always be tried for, but can be got only under the following conditions: when the sides of the wound can be accurately brought together; when they are not displaced by bleeding or exudation of matter; when the wound is left quiet and protected from outward injury; and when it is kept perfectly free from impurity.

2. The second mode of healing takes place slowly, with suppuration and the formation of granulations, leaving a large red scar.

It is the matter formed in the process of suppuration which separates the sides of the wounds. When the wound begins to heal, granulations form. These granulations, by degrees, and with constant suppuration, fill up the wound and are finally covered by a large scar, which remains red for a long time. Suppuration and putrefaction open the door to other dangerous surgical ailments, of which many people die after wounds and operations.

Modern surgery has made wonderful progress in the treatment of wounds, chiefly because a more accurate knowledge of the causes of suppuration and putrefaction has taught us how to prevent these processes, and how to guard against many of the dangers to which they give rise.

How to Treat Wounds. The first thing in the case of a wound is to stop the bleeding as already directed. The next is to cleanse it gently, as far as possible without disturbing any blood-clot that may have formed. After that, bring the edges of the wound as closely as possible together, and secure them there by little strips of plaster, the skin being well dried first. Apply the dressing of a pad and bandage, support and keep the injured part at perfect rest, and then attend to the person's general comfort.

Clean-cut wounds heal quickly and easily if all dirt is removed and the edges are brought close together. The pad should be dry, or soaked in a little olive or carbolic oil, and if the wound does not become unpleasant, the dressing may be left for three days.

Torn wounds cannot be closed up, but require cleansing, and the pad must be constantly soaked in plain cold water. Crushed wounds and stabs are to be treated in the same way.

Poisoned wounds are caused by the bites of mad dogs, poisonous snakes, and by poisoned weapons. The danger of these is that the poison from the wound may by means of the lymphatics be carried to the heart, and so poison the whole blood.

To prevent this diffusion of the poison one should, without loss of time, bind the limb round tightly above the wound; this is best done with an elastic belt or a strap or string, or a handkerchief made tight by means of a stick twisted round in it. When this has been done, try to get rid of the poison from the wound. This may be done by sucking it out (if the lips are not sore), by burning with hot coal, hot knife or knitting-needle, or by caustic (carbolic acid, nitric acid, etc.).

In gunshot, and all other *serious* wounds, all that can be done is at once to arrest the bleeding and send for a surgeon.

Bones are hard but brittle, and break like glass or porcelain by outward force—by a blow, fall, or jump—often with a snap or crack which may be heard and felt.

Fractures. Fractures are divided into two kinds—simple and compound. We call a fracture *simple* when the skin is not injured. We call it *compound* when it is accompanied by a wound, caused either by the same force which produced the fracture—a bullet, for instance—or by the ends of the broken bone protruding through the skin.

Compound fractures are much more dangerous than simple ones, because the skin and muscles are always much bruised at the same time, and because dirt may get into the wound and be with difficulty removed.

How do we know when a bone is broken? In four ways: (1) The limb is bent or shortened; (2) there is an unnatural degree of movement at the seat of the fracture; (3) there is violent pain; (4) when the limb is moved the broken ends of the bone may be felt grating against each other.

How does a fracture heal? New bone-substance (*callus*) is formed at the broken ends of the bone and knits them together. This new substance is at first soft, but hardens gradually into bone.

In all cases, therefore, when you have any reason to suspect broken bones, from the pain or the helplessness of the limb, be very gentle and make the person keep quite still. Cut the clothes off the part. See where the fracture is, but move the bones only so as to place the limb in a straight line in its natural position, and then put splints on the inside and outside and back of the limb, and secure them firmly round it by bandages above and below, so that the broken part is fixed and quite immovable. Splints can be formed out of umbrellas, boards, cardboards, sticks, rolls of newspapers, cricket stumps, rolls of rushes, bark of trees, and can be tied on with anything. Thus secured, the patient can be moved with safety on a board, stretcher, or even carried in the arms.

When a jaw is broken, tie it up firmly, by a bandage under it to the top of the head. When ribs are broken, put a broad roll of flannel or linen round the part, and let the patient sit up till the surgeon comes. When a collar-bone is broken, tie the arm to the side with a large pad in the arm-pit till the surgeon comes. In the case of any other fracture, apply splints as directed, and be sure that they are secured above and below the broken part.

Treat any case when you *think* the bone is broken like this; and even if you are wrong, you have done no harm, and have certainly made a mistake on the right side. A surgeon must, of course, be sent for at once.

Dislocation and Sprains. In the case of dislocation, some limb is suddenly put out of joint by over-use or by an accident. You may think it is a broken bone, because the limb is fixed and cannot be moved without pain. But then you remember that though when the bone is broken the limb is helpless, it is not fixed, but very movable at the broken place, and that it is your business to fix it up in splints.

If in doubt as to whether it is a broken bone or only a dislocation, always act as if it were broken and put on splints. Do not try to set the bone yourself.

A sprain is a wrench to a joint; a strain is over-exertion of a muscle. In a sprain, which happens most frequently to the ankle, if at all severe, always send for the surgeon. Neglect of this precaution may lead to serious results.

In the case of sprains, therefore, let the part have complete rest, laying it on a pillow. Elevate the leg (if it be the ankle), and apply cold, either in the form of ice (broken in pieces in a sponge-bag and resting on the joint), or sponge with cold water or with spirits and water. If the pain is still very bad, very hot fomentations may relieve it.

In a case of strain or cramp of the muscles, rub them steadily with warm oil.

Burns. Both burns and scalds arise from the same source, but the one kind is caused by dry heat, and the other by moist.

If a person's clothes are on fire, the one thing to do is to lay him flat down on the floor, roll him over on to the burning part of his clothes, and cover him as he lies with a thick rug; and lastly, if needed, drench him with cold water.

With regard to treatment in slight cases, a little flour dusted on the part at once, so as to form a crust, is very good. In more severe cases, any burnt

parts of dress, etc., should all be cut off first, and the wounds dressed with strips of rag soaked in sweet oil, and then covered with cotton-wool. The blisters that form so quickly should never be broken, but, if large, pricked at the lowest part, and the shrivelled skin not cut away, but left. The surgeon, of course, must be sent for at once. The person must be kept warm, and be given some hot drink.

Scalds require the same treatment, except that as much of the scalding liquid should be washed off as soon as possible.

Burns from strong acids or alkalies, such as vitriol, spirits of salts, or caustic soda, potash or lime, should be first drenched with water, and then, if from an acid, bathed with soda and water; if an alkali, with vinegar and water.

Burns of the face are best treated by painting with olive oil on a feather or brush.

Poisoning. In cases of poisoning, at once send for the doctor; but as he is sometimes a long time coming, and promptness of action is often a matter of life or death, a few very definite instructions are absolutely necessary.

Find out at once (if possible) what has been taken. If it is a strong acid, as vitriol, spirits of salts, etc., etc., give soapsuds, plaster from the wall or ceiling, chalk, or soda in water. If it is a strong alkali, soap lees, caustic soda, lime, or potash, give a glass of vinegar and water. Afterwards give, in either case, a tablespoonful of olive oil.

If it is any other form of poison, give two teaspoonfuls of mustard in a cup of warm water, or any other emetic that may be handy; or get half a teaspoonful of sulphate of zinc and give it in water. Carefully preserve all bottles and all vomited matter, as the case may be one for legal investigation.

When anyone is stung, apply ammonia (sal volatile) to the part, and extract the sting if left in.

Unconsciousness. The chief causes of loss of consciousness are: (1) injuries to the brain, with or without fracture of the skull; (2) diseases of the brain, apoplexy, epilepsy, etc.; (3) poisoning by narcotics, opium, morphia, alcohol, ether, and chloroform; and by retention of urine, the result of kidney disease; (4) fainting, paralysis of the heart through fright, pain, exhaustion, loss of blood, etc.

As it is often very difficult for the best medical man to determine at once with what form of unconsciousness he has to deal, it would be useless to attempt to tell how to distinguish between and recognise these conditions. What should be done, however, in all cases, is this:

1. Remove all tight clothing from about the neck—neck-tie, collar, shirt-studs, etc.—as these interfere with the flow of blood from the head.

2. Give free access to fresh air round the patient, and send all useless bystanders away.

3. Place the body on the back with the head low, if the face is pale, as in faintness after great loss of blood. If the face, however, is red, the head must be raised. If sickness sets in, the head should at once be turned on one side, so that the vomited matter should not be drawn into the lungs.

4. If the patient no longer breathes, which can be ascertained by holding a looking-glass or flat piece of metal, or a feather, before the mouth and nose, then we should at once have recourse to artificial respiration.

5. Send as quickly as possible for medical aid, or transport the patient without delay to the hospital.

Insensibility may occur without a fit. You may have to decide before the doctor can come whether a man is under the influence of drink or dying, and this is exceedingly difficult. Open the person's eyes, and if both pupils are very small, he is very likely asleep. Wet a towel, and gently slap his cheeks; you will suddenly see the pupils enlarge. This shows he is now awake, though possibly still insensible. If they dilate very much, and there are general signs of drink, he is probably drunk; if one pupil remains small, and the other large, it is probably an injury to the brain. If both remain small and cannot be altered, he is probably drugged.

Of course, these rules do not always hold good. Your duty is clear—send for a doctor in all cases at once.

In an apoplectic fit, the person falls down suddenly, and is always more or less paralysed. Send for the doctor at once. Give the person fresh air; let him lie quietly with his head a little raised; loosen all tight clothing, put hot bottles to his feet, keep the room quiet, and give him nothing by the mouth.

Fainting. Fainting is a common and an alarming occurrence. If you see a person turning deadly pale, and about to "go off," you may prevent his doing so by steadily pressing his head down between his knees till his face is quite red. If he has fainted, let him lie flat on the floor. On no account allow him to be raised. Loosen everything round the neck, and let him have plenty of fresh air, a little cold water in the face, and smelling salts. A teaspoonful of brandy and water may be given if the face is very pale.

Drowning. In drowning, the action must be very prompt, and you must have a clear idea of what to do at once. First turn the body over on the face, and let any water escape by the mouth. Then wipe the mouth and nose dry; apply ammonia to the nose, or put a feather down the throat; rub the chest with hot cloths, or beat it well with the end of a wet towel. If in a short time breathing does not begin, adopt immediately this method:

Place the patient on his back with a firm cushion under the shoulders. Draw the tongue out of the mouth and fix it with an elastic band over it and under the chin, or a piece of tape. Take off the braces and all tight clothing; kneel or stand behind the person, grasp his arms above the elbow, and draw both arms well back over the head, and keep them at full stretch so as to expand the chest while you count ten rapidly; then bring the arms forward and downwards, and press the elbows well into the sides of the chest, and hold them there, counting ten again. Then repeat this slowly about 15 times a minute, until a natural breath is drawn, when you at once proceed to warm the patient, and rub his legs and arms up towards his heart. Put him in blankets, if possible, during this treatment. When he can breathe, give him a little brandy.

Be sure the tongue is well stretched out during your efforts, and that people do not crowd round. As in every other serious case, this only "until the doctor comes."

If a person is choking, seize his nose at once with one hand, and push the finger of the other hand right down the throat, and try to hook up or push down the obstruction. If unsuccessful, slap the back vigorously, or tickle the throat and try to bring on vomiting.

Concluded

TEACHERS & SECRETARIES

The School Teacher's Training, Salary, and Prospects. Public and Private Schools. Posts at the Universities. The Private Tutor. Secretaries

By W. H. STUART GARNETT

It will be well at the outset of this article to indicate in some degree its scope, and the meaning which we propose to assign to the term scholastic professions.

Strictly, the term should include all those concerned in imparting to others the education which they have themselves received, whether by writing, preaching, or personal instruction. It is not our intention to deal in this article with the literary professions: it is with the teacher proper that we are concerned—with the man or woman who gives direct oral instruction, or supervises the work of the pupil in school, gymnasium, or workshop. We shall endeavour to indicate briefly the course of training and the prospects to be enjoyed by the academic, the technical, or the physical teacher in every grade.

To the academic teachers three great careers are open—those of elementary, secondary, and university instruction, as well as the less satisfactory one of private coaching. Of these, by far the most important—at least, considering the number of persons engaged in it—is the profession of elementary school teaching.

Elementary School Teachers. In the past this profession has been divided by a marked line of cleavage between the teachers in Denominational and in Board schools, of whom the latter had—financially, at least—much the better position. Elementary school teachers are drawn almost entirely from elementary schools, and the supply is at present considerably less than the demand. Very few of these teachers have private means, and the local authorities have, therefore, found it necessary to take charge of their education from the earliest stage, setting them apart for their profession from youth up like the Catholic priests of the Middle Ages.

Pupil-teachers. In the old days the future teacher became a pupil-teacher at the age of thirteen or fourteen, when the compulsory school period ceased. In return for a hard day's work the child received a small wage and the privilege of being taught by the headmaster after school hours. This went on until the age of seventeen or eighteen, when the pupil-teacher took the King's Scholarship examination, and, if successful, entered a training college.

The Board of Education have now very properly decided that no teaching is to be done by children under sixteen. The local authorities have, therefore, to provide by scholarships for the education of children up to that age. Generally these scholarships are awarded on examination at the age of twelve [see Ladder of Learning, page 481], and carry free education at a secondary school up to the age of sixteen. In London the examination is taken at the age of eleven, and about 2,000 junior scholarships are awarded every year. Of the successful candidates, rather more than half become teachers. These scholarships include, in addition to free secondary education, a grant of £5 a year for the first three years, and £15 a year for the remaining two.

The London elementary school child has a second chance of becoming a teacher by winning a "probationer" scholarship at the age of fourteen. These are open to future teachers only, and admit them to the ranks of the junior scholars.

At the age of sixteen the child definitely takes up his or her profession, and becomes a pupil-teacher, remaining at the secondary school, or entering a pupil-teachers' centre, but teaching at the same time in a public elementary school. The salaries of pupil-teachers are given in the following table. The salaries in the great provincial municipalities are intermediate between the two.

PUPIL TEACHERS' SALARIES

	First Year.		Second Year.	
	London.	Country.	London.	Country.
Boys ..	£32 10s.	£17 10s.	£39	£20
Girls ..	£20 16s.	£17 10s.	£26	£20

The King's Scholarships. The most critical moment in the life of our future teacher comes at Easter, after he has been a pupil-teacher for a year and a half. At this stage he enters for the preliminary certificate examination, which entitles him, if successful, to a King's Scholarship. This scholarship is paid only to the student who gets into a training college. The grant is £53 a year to a man, and £38 to a woman, in a residential college; or £13 a year to a student of either sex in a day training college. As this grant is not quite sufficient to cover the cost of training, most residential colleges charge an "entrance fee" not exceeding £25. This fee is paid for London students by the County Council, who also pay a special grant of £20 to students in day training colleges. A full list of recognised training colleges, with fees, etc., is contained in the regulations for training published by the Board of Education.

The number of teachers required annually to supply all the elementary schools in England is about 10,000, of whom something like three-quarters must be women. Unfortunately, the whole available accommodation in training colleges is for 1,677 resident men, 3,537 resident women, and 3,751 day students. It follows that only about 5,000 students can be received in one year, and a number of people otherwise qualified must be rejected.

The great majority of these training colleges belong to the Church of England, though, of course, it does not follow that they are open only to Churchmen. The Board of Education are putting pressure on local authorities to increase the number of colleges provided by them; but it is not surprising the local authorities contend that the teachers they train may not remain in their service, and they urge, with reason, that the whole cost of training should be borne by the State.

The Untrained Teacher. The lack of accommodation has excluded, and still excludes, many future teachers from the training colleges,

and it is only natural that some preference has been shown to Churchmen in the Church colleges. This has in the past been a very serious hardship to Nonconformist teachers, though the Education Acts of 1902-3 did a great deal to improve their position in this respect.

The teacher shut out from the training college has practically no alternative but to begin work at eighteen as an untrained teacher, and to endeavour by private study to qualify for the Board of Education certificate. These "untrained, uncertificated" teachers are paid in London a fixed salary of £70 for men and £60 for women. The salaries paid in the provinces are about the same.

Normally the training college student takes the final certificate examination after a two years' course, and immediately begins teaching in a public elementary school. The student who takes the final examination after a one-year's course commands usually a rather lower salary at first. A few of the most brilliant students are frequently kept on at the training college, or sent abroad for a third year, with a Government grant, and these become teachers either at a secondary school or in the training college itself.

Salaries and Prospects. The accompanying table shows the starting salaries of certificated teachers with the various qualifications referred to. The maximum to which salaries rise is also shown. In London, men's salaries in elementary schools rise to £200, by increments of £5 a year during the first two years, and £7 10s. a year thereafter. Women's salaries rise by increments of £4 a year to £150.

SALARIES OF CERTIFICATED ELEMENTARY SCHOOL TEACHERS

—	—	Trained Teachers.		Untrained Teachers.		
		1st or 2nd Class Cert. or passed in 1906.	3rd Class Cert.	1st or 2nd Class Cert.	3rd Class Cert.	Passed in 1906.
Men	London	£100	£90	£85	£75	£80
	Rural Counties	85–130	80–120	70–90	70–90	
Women	London	88	80	76	70	75
	Rural Counties	75–110	70–100	60–75	60–75	

Head Teachers in Elementary Schools. Nearly all elementary school head teachers are drawn from the ranks of the assistants. A period of some years' service is commonly required, and the salaries offered to head teachers in the smaller schools are from £10 to £20 a year better than those paid to assistant teachers of the same standing. In the large schools which are found in London and the Midland towns the head teacher occupies a very good position. We give the London scale of salaries for head teachers.

SALARIES OF LONDON ELEMENTARY HEAD TEACHERS

Accommodation in School.	Men.	Women.
1–200	£10 more than salary under scale for assistants.	
201–400	£200–£300 (Increased by £10)	£150–£225 (Increased by £8)
401 and upwards	£300–£400 (Increased by £10)	£225–£300 (Increased by £8)

Head teachers in higher grade schools receive £15 a year above scale. The maximum salary paid to head teachers in most country districts is from £200 to £250.

Advantages of Elementary School Teaching. An elementary school teacher has the advantage of beginning remunerative work at a very early age as compared with those who follow the other liberal professions. Further, his training costs him practically nothing, and his salary increases very quickly, so that at the age of thirty-five or so, when he may expect to be burdened with an expensive family, his earnings have already touched the top limit.

The demand for teachers, as we have already pointed out, exceeds the supply, so that there are practically no unemployed in the profession. Retirement at sixty-five is compulsory, but the superannuation fund, if the teacher is wise enough to subscribe to it, provides a liberal pension. The work is not heavy, as it is confined strictly to school hours—that is, from twenty-five to thirty hours per week.

The prospects of promotion, too, are good. Every year some seven per cent. of the teachers employed in elementary schools are promoted to headships. A certain number migrate to secondary schools, and the establishment of such schools by the municipalities has opened a new and wide door of transition; while the recommendation of the consultative committee, that higher elementary schools should be staffed principally with elementary school teachers, has offered a new prospect of advancement.

On the whole the career offers more attractions to women than to men. The woman teacher receives, it is true, a smaller salary than the man; but, as compared with their respective earnings in other professions, the scale of pay is more liberal. Partly for this reason quite a number of girls from secondary schools and colleges become elementary school teachers without going through the normal course of pupil-teachership and the training college. Male teachers, on the other hand, are nearly all supplied by the pupil-teacher system.

Secondary Schools. Secondary schools differ widely in the prospects which they offer to the teacher. Their classification is somewhat difficult, as it is impossible to draw a hard and fast line at any point between Eton College and the small country grammar school. At the same time, it is necessary to recognise the distinction, and we shall designate the latter, together with the majority of London secondary schools, as schools of the second grade, reserving the term "first grade secondary schools" for those of public school standing.

The term "first grade secondary school" will, of course, include the girls' high schools, and such well-known boarding schools as St. Andrews and Wickham Abbey.

Second Grade Secondary Schools. In all secondary schools the majority of the teaching posts are filled by men with university degrees, or women with equivalent qualifications. In the second grade schools there are generally quite as many graduates from the new universities as from Oxford and Cambridge. Trained teachers are in a minority, but a few will be found—these have usually spent a third year either at the training college or abroad, but some have risen from elementary school teaching.

Generally speaking, the position of an assistant teacher in such a school offers little scope for the man of ambition. He may, it is true, secure a berth in a first grade school, but this is unlikely; he may, if employed in a municipal school, be promoted to the headship, but this can happen only to one man in fifteen or twenty. For promotion to the head-

ship of any other school a university degree is practically a sine qua non, and in the boys' schools the chances of any but an Oxford or Cambridge man are small. These heads are largely drawn from among public school masters, so that the secondary school master has a small chance of promotion as compared with the secondary school mistress, but his salary compares with hers more favourably than in the elementary schools.

Secondary School Teachers' Salaries. For the expenses and difficulties that must be faced in the course of training by the intending secondary school teacher, and for the helps by the way in the shape of scholarships and free places, the reader is referred to the articles on the Ladder of Learning [page 481].

The demand for such teachers at the present time is great, employment is certain, and the salary and social position of the teacher are rising. The salaries offered vary very much, but a qualified male assistant teacher may expect to earn from £120 to £250, and a woman teacher from £100 to £200 a year.

The Girls' Public Day School Company offer salaries starting at amounts varying from £70 to £135, and rising to £200 a year. Secondary schools in London and the large municipalities are rapidly approaching the standard of pay set up by the London County Council, who offer to assistant masters a salary rising from £150 by £10 increments to £300, or in special cases to £350, and to assistant mistresses a salary rising from £120 to £220 by £10 increments.

The salaries paid to secondary school teachers by the provincial municipalities may be gathered from the following instances of starting and maximum salaries of trained certificated teachers.

District.	Men.	Women.
London . . .	£100–200	£88–150
Edinburgh	85–160	65–110
Hornsey	95–200	85–150
East Ham	90–175	75–130
Birmingham	85–150	70–100
Lancashire	80–140	70–110
Leeds	85–150	75–100
Manchester	85–140	65–110
West Riding	90–135	80–105

It need hardly be mentioned that the work of secondary school teachers, including correction of exercises out of school hours, and in some cases presence in the playing-fields, is very much harder than that demanded of an elementary school teacher.

Subjects Taught. It must be remembered by the intending teacher in this class of school that by far the greater number of his pupils will be destined for a commercial or industrial life. Consequently, he may as well spend his time on Greek verbs as on Hebrew paradigms. The study of elementary mathematics, science, and above all, of modern languages, bulks larger in the second grade secondary schools than in either the public school or the elementary school. A special training in either science or modern languages is very valuable to the would-be teacher. A man or woman who has spent a year abroad can generally command additional pay on the strength of it; and many of the larger boys' schools employ a "head science master," at a salary of some £400 per annum. Such a post is within the reach of the non-graduate, and is a stepping-stone to the headmastership.

The salaries offered by the London County Council to head teachers, and recommended to all secondary schools aided by them, depend on the accommodation in the schools. The scale is given below.

HEAD TEACHERS' SALARIES IN SECONDARY SCHOOLS		
Accommodation.	Head Masters.	Head Mistresses.
1–200	£400–£500 (Increasing by £20)	£300–£400 (Increasing by £10)
201–400	£400–£600 (Increasing by £20)	£300–£450 (Increasing by £15)
Over 400	£600–£800 (Increasing by £20)	£400–£600 (Increasing by £20)

In secondary schools other than the municipal ones payment by a capitation fee is common. The Girls' Public Day School Company offer in some cases a nucleus salary of £250, together with a capitation fee of £1 10s. to £2 on the pupils in the school. For the most part the salaries offered are rather lower than those on the scale set out above.

First Grade Secondary Schools. The public schools demand rather different qualifications in their masters than the secondary schools of the second grade. In the first place an Oxford or Cambridge degree is almost essential; in the second place, a professional training is hardly considered, and a knowledge of modern languages or of any scientific subject is required only of perhaps one master in twenty. Masters are frequently appointed at the conclusion of their university course, though in some cases the heads will advise a few terms' experience elsewhere.

The distinction between schools of the first and second grade is largely social. Partly for this reason the public schools are inclined to insist that the masters appointed should themselves be public school boys. Naturally, old boys of the school itself have a great advantage in competing for posts—at Eton, probably half the masters are old Etonians.

Local traditions are much less strong in girls' schools, and social distinctions are less felt. The teacher requires much the same qualifications as for secondary school work, but a university degree is very commonly required.

The Athletic Schoolmaster. Some attention is naturally paid to the athletic prowess of an applicant for a post, though less than in a private school, and certainly less than is commonly believed; still it is quite sufficient to turn the scale as between a football or cricket blue and a "mere man" of similar intellectual attainments. This is largely due to a sense of the disciplinary effect which such a distinction will have on the somewhat turbulent lower boys of a public school.

Whatever the reason, athletic qualifications are of value to the future schoolmaster, and, naturally, prowess in cricket or football, which can be displayed in the playground, is more to be desired than distinction in rowing or other sports. Many a good oar at Cambridge has been spoiled to make a cricketer, because the undergraduate in question contemplated teaching as a career.

The important qualifications, then, for a public school master are—and the first is almost essential—an honours degree, a public school education, and athletic prowess.

The Public School Master's Salary and Prospects. The rewards offered vary greatly. Probably the best assistant mastership in the world is that held by a classical master at Eton. His salary starts at £300 a year, but he

has the right and the leisure to take forty private pupils at twenty guineas a head. Coupled to that the prospect of a house of forty boys after thirteen years' service, and you have a post which few men would exchange for the headship of any but a first-class public school.

The salaries in most public schools are from £250 to £400 a year for non-resident masters, and about £100 a year less for residents; usually, however, only junior masters are appointed to resident posts, with the exception of those masters who have houses of their own.

School Boarding-houses. In many boarding-schools there is a schoolhouse, which is either an appanage of the headship or belongs to the school itself; but in almost every school the majority of the boarders are distributed to private masters' houses, over which a certain amount of supervision is exercised by the school authorities.

Whether this is a desirable arrangement or no is a question much debated. It is urged, on the one hand, that it is essential that all the details of boarding-house administration should be supervised by a master. This may be granted, but it is at least open to question whether the supervising master ought to be financially interested in the housekeeping, and it is very strongly contended by many masters—who have not houses—that the business of an unlicensed victualler is beneath the dignity of the scholastic profession.

However that may be, the prospect of having a house is one of the principal baits which attract the public schoolmaster. The annual profits to be made out of such an establishment may be fairly accurately assessed as from £10 to £25 per boy, according to the wealth and standard of luxury prevailing among the parents who patronise the school. Naturally, the whole profit depends upon the house being full; it is the last four or five boys who pay, and the expenses of running the house are heavy, so that a boarding-house can hardly ever promise a safe or steady income.

Public School Headships. The prospect most cherished of the average assistant master or mistress is that of becoming the head of a first-grade school. The headmistresses for the most part receive salaries of from £500 to £800 a year, but those of the large boarding-schools probably make a total income considerably larger than this.

Headmasterships of public schools, on the other hand, are worth altogether from £1,200 to £5,000 a year. In the modern schools a great part of the headmaster's income consists of capitation fees on the number of pupils in the school, but the older and more venerable public schools, admission to which is sought by many more boys than can possibly be accommodated, naturally despise the capitation fee, and pay for the most part a fixed salary.

Many schools demand that the headmaster should be in orders, and in the case of boarding-schools with chapels attached this requirement is almost universal. The great day schools, however, have of late shown considerable disposition to appoint laymen, and in practically no case does it help an assistant master to be in orders, though he may find it useful to enter the Church before applying for a headship.

Private Schools. It is difficult to generalise as to the private schools dotted about the country. Comparatively few are open to inspection, and the available data are scanty. The owner, like every other capitalist, seeks as a rule to buy his commodity—teaching—in the cheapest market and to sell in the dearest.

Of late years these schools have been, to some extent, opened to inspection by the much abused Column B of the teachers' register. University graduates and others seeking recognition as secondary school teachers are often willing to accept a smaller salary in a *recognised* secondary school in which they can qualify, than they might demand in a school not so recognised. This is a strong inducement to owners to seek recognition, and to open their schools to inspection by the Board of Education.

So far as the assistant teacher is concerned, the position offered by a private secondary school differs little from that in other second-grade schools. Salaries are for the most part low, and the work is apt to be heavy, although this is by no means the universal rule. Private preparatory schools for the great public schools—particularly "scholarship hunting" schools—pay very well indeed, besides affording the masters excellent opportunities of promotion into the schools for which they prepare pupils, as such masters, being well known to the authorities, are frequently sent for to supply temporary vacancies on the staff of the public school.

In these schools a good degree is naturally looked for in the assistant master, and in all boys' private schools athletic attainments are very highly thought of, since the reputation of a private school depends in no small degree on the subsequent achievements of its pupils in the public school playing-fields.

Starting a Private School. The headmaster of a private secondary school is very commonly the owner. From his point of view it is largely a commercial undertaking, and its success depends on many other things than his academic qualifications. The would-be headmaster must have command of capital, and, as a general rule, it may be taken that the minimum capital cost of providing a secondary school with proper accommodation and fixtures is £30 a head in London, and rather over £20 a head in the country. The cost of providing a boarding-school will be rather more than twice as great.

Private schools for girls are in a peculiar position, since they usually lay stress upon their exclusiveness. The mistresses in such schools are chosen as much for their "accomplishments" as for their intellectual attainments, and in many cases the staff is practically synonymous with the family circle. The principal qualification for an assistant mistress is a knowledge of modern languages. It is naturally impossible to give any account of the very diverse rates of pay prevailing in these establishments. They probably compare very unfavourably with those offered to secondary teachers by the municipal authorities.

The Universities. Unquestionably the most desirable of all academic posts are those at the old universities, carrying, as do the best of them, a very fair salary, great dignity, and demanding, it must be confessed, very little work.

The teaching staff of every university consists of professors, lecturers, and demonstrators. Lecturers in scientific subjects are commonly demonstrators at the same time, and the teaching work which they do in many cases occupies only a part of the week, so that it is combined with study. This is more particularly the case in the American and Colonial universities, where such posts offer an excellent opportunity to British graduates to continue the study of special subjects under other auspices.

Demonstrators and Lecturers. The demonstrators and lecturers at a university are in almost every case chosen from among the more brilliant students at the close of their university course, so that the able student with no definite ambitions outside the university finds himself transformed almost imperceptibly into a lecturer on a salary of £150 to £200 a year. At Oxford or Cambridge the lecturers are nearly all Fellows of their colleges, and do private coaching as well, so that their total earnings not infrequently amount to £600 or £700. As a class, however, demonstrators and lecturers are—for the best men of their academic year—very poorly paid. Probably they have the best brains in the county.

Professors. The lecturer, after a few years' service, not infrequently migrates to some sister university in Great Britain or the Colonies, to fill a professorial chair, or else becomes head of a department in a technical institute. Most British professors are trained at Oxford or Cambridge, and probably a very large number of the present ones have served at the old universities as lecturers of the colleges or of the university. Such professors not infrequently return in the end to the university at which they were trained.

The emoluments attached to the various chairs at the new universities vary from £500 to £800 per annum. A few special chairs are still more liberally endowed. The professors at such universities are the actual teaching heads of the faculty, and have a great deal of real work to do, though most have leisure for literary work or for a certain amount of outside practice as scientific experts. The executive heads of the various universities are paid rather more highly than the professors, and the principal of London University draws a salary of £2,000 a year.

Professors at Oxford and Cambridge draw from £700 to £1,200 a year, and have very little actual teaching to do. They are no doubt in a large measure responsible for the educational policy of their respective faculties, but personally they do not as a rule give more than one or two courses of lectures in the year. The intention of the universities in filling these chairs is rather that their occupants should be free to engage in scientific or literary research, to the glory of their alma mater.

It is unnecessary to go into detail as to the infinity of college appointments from the mastership downwards. The first step to all of these is the college fellowship, which is given to the able student either with or without examination. The fellowship is the natural goal of the academic career, and comes, with its attendant appointments, almost automatically upon the brilliant scholar.

Colonial Universities. Salaries at Colonial universities range between much the same limits as at the English provincial ones, the professors receiving from £500 to £1,000 per annum. The assistants, however—demonstrators and so on—work usually only for half their time at these occupations, and have considerable leisure and opportunities for study. Salaries range from a small sum up to £150 or so.

Since the ablest students at these universities are commonly desirous of proceeding to Oxford or Cambridge, and since the inducements offered to young university men to take up an industrial career are greater in the United States and in the Colonies—where education is highly valued—than in England, it is not always easy to fill the inferior teaching posts in the Colonial universities. The result is that there is a considerable opening for English university men in Canadian and other universities, and an Oxford or Cambridge graduate is warmly welcomed.

These opportunities should be much more used than they are by Englishmen. Not only do they form an excellent "landing place" in the Colonies for men anxious to take up an industrial or scientific career there, but they afford an excellent training for many professions at home. A year or two at McGill University, in Montreal, for instance, is at once an invaluable experience to a British college-trained engineer, and at the same time opens to him the doors of all the great workshops in America.

Unfortunately there is no adequate system of communication between British and Colonial universities, by means of which these posts may be brought to the notice of students at home.

Technical Institutes. Nearly all that we have said of the universities applies to technical institutes, except that the scale of salaries is, on the average, about 40 per cent. lower than at the universities; a few, however, of the principal institutions, such as the Municipal School of Technology at Manchester, deserve rather to be classed with the universities in this and in other respects.

The demonstrators at the polytechnics are picked out, as in the universities, from among the day or evening students of those institutions. The salaries offered are from £50 to £100 a year, quite sufficient to tempt a boy without capital who realises that the most brilliant career in the institute is not an absolute guarantee of success in the outside world. The work involves both day and evening teaching, and is therefore by no means light; but the prospects are good, as the lecturer may well rise to be the head of his department.

Heads of departments at the London polytechnics are commonly paid from £200 to £500 a year. They are in many cases university men, and occasionally return to the new universities as professors, or go out to the Colonies in the same capacity.

The principals of the technical institutes receive salaries of from £500 to £700 in the provinces, and from £600 to £800 in London; except in the case where heads of departments are appointed to these posts, it is generally required of a candidate that he should have had previous experience in the conduct of an educational institution. Headmasters of secondary schools are not infrequently appointed.

Training Colleges. The training colleges are in a sense technical institutes. They teach a profession, and they draw their teachers from the ranks of their own students like the polytechnics. They are, however, mostly residential colleges, and the staff is resident in nearly every case. The scale of salaries in municipal training colleges is generally about the same as in the larger secondary schools, deducting the cost of maintenance of the teacher.

Generally it may be said that the assistant teachers in training colleges draw from £100 to £200 a year if men, from £70 to £150 if women, in addition to their board and lodging. These teachers very generally move into secondary schools after a few years, with a view to freedom from the necessity of residence.

The pay of head teachers is about the same as in technical institutes, £450 to £700 a year. These head teachers are nearly always graduates, sometimes of Oxford or Cambridge.

Private Tuition. We have spoken of the highest scholastic posts as falling to the most successful scholars who have reached their degree with no definite aim in life. Unfortunately there are

many such, into whose mouths the academic plums do not drop. Having no definite professional training and no settled purpose, their obvious means of livelihood is that of imparting the knowledge they have acquired.

Of these men some become masters in public or private schools, but the majority drift into private coaching outside the University. The usual fee for a graduate coach at Oxford or Cambridge is 7s. 6d. an hour. In London and elsewhere the usual fees are 5s. and upwards for men, and 4s. and upwards for women. The non-graduate must take what he can get, and many of his competitors are working for 2s. 6d. an hour.

Private coaching is not to be recommended as a serious profession. When fresh from the university a man is able to make an income by this means, which compares very favourably with that which he commands in a secondary school, and he may well spend a few years in coaching while looking out for an opening into some more substantial profession. On the other hand, he must remember that there is no certainty of employment. Methods of teaching change, and the coach of forty years of age, instead of bettering his position, is already beginning to suffer by the competition of younger men; whereas a regular teacher is nowhere superannuated before the age of fifty-five, while university appointments are nearly all for life.

Special Subject Teachers. Outside the ranks of academic teachers are those who teach crafts, whether industrial, commercial, or domestic. Most of these teachers are employed by the local authorities in day or evening classes, and since their services must be secured by the councils in the open market and in competition with private employers, the scale of fees paid by the London County Council for this class of work may be taken as very fairly indicative of those which the teacher may expect to command. It need hardly be mentioned that the demand for this class of teaching exists only in the large towns, where the conditions are much the same throughout Great Britain.

The special subjects—gymnastics, swimming, needlework, etc.—taught in elementary schools are usually taught by members of the regular staff; but, for the secondary schools, instructors are engaged at substantially the same rates as for the evening classes.

The Teaching of Crafts. The craft school has risen on the ruins of the apprenticeship system. A century ago the boy learnt his trade in the workshop from the man whose bench he shared. Now the value of floor space has killed apprenticeship in the large towns, and the boy goes to a trade school or technical class instead; but the man who teaches him in the school workshop must have the same qualifications as the man who taught a hundred years ago. In fact, the teacher of a skilled trade is, and must be, an artisan of practical experience, though as a very highly-skilled artisan he may command wages of 2s. or 2s. 6d. an hour. It is a valuable qualification for a trade teacher of this class to have taken an evening course in the theory of the subject of which he teaches the practical side.

In the same way the teachers of other technical subjects are craftsmen. The teacher of book-keeping is frequently a practising accountant, and the teacher of "first aid" a practising surgeon. The possibility of obtaining work of this character should be borne in mind by men starting in the skilled professions with a good college record behind them.

The teachers of gymnastics are drawn from a number of different classes. The great majority of the male teachers are retired Army instructors or non-commissioned officers. The best posts go commonly to men and women trained in Germany, or in some of the London schools. The South-Western Polytechnic has trained a number of very successful teachers, and Madame Osterberg's College at Dartford has an equally high reputation.

Special Woman's Work. The special subjects for which instructresses are required are art, swimming, nursing, needlework, and domestic economy, which includes cookery, laundrywork, and housewifery. The art work and the swimming are largely day subjects, but almost all the other special teaching is done principally at night.

Art teachers are usually, and domestic economy teachers invariably, required to have had special training as teachers. [For the training colleges available see Ladder of Learning, page 481.] The London County Council require domestic economy teachers to possess a diploma, and art teachers the art masters' certificate. The salary of domestic economy and needlework teachers in London rises from £80 to £120 a year by £5 increments. The salary of art masters rises in the same way from £175 to £200, and of mistresses from £125 to £150 a year.

The following is the scale of pay of special subject teachers in London evening schools.

RATE OF PAY IN LONDON EVENING SCHOOLS FOR MEN TEACHERS

Subject.	Evening Schools. (For evening of 2 hours.)	Commercial Centres. (For evening of 3 hours.)
Regular teaching	7s., or £13 6s. 8d. per ann.	15s., or £25 per ann.
Assistant teaching	5s., 4s.	—
Science and Art and Commerce	6s.	7s. 6d.
Special Commercial subjects ..	—	10s. 6d.
Manual training and Crafts ..	5s.	7s. 6d.
Gymnastics ..	7s. 6d., 5s., 4s.	—
Swimming	6s., 5s.	—
Literature	10s. 6d.	—
Nursing, etc., by doctors	£1 1s.	—
FOR WOMEN TEACHERS		
Swimming	5s.	—
Cookery and Laundry	5s., 4s.	—
Housewifery ..	6s., 5s.	—
Nursing (trained)	10s. 6d.	—

Inspectors. There are two educational inspecting authorities—besides the Treasury, which employs a very small staff—the Board of Education and the Local Authorities. The inspectorate under the Board of Education is a branch of the Civil Service outside the scope of this article. We may mention that the qualification is a first-class degree at Oxford or Cambridge, and the salaries rise from £200 to £800.

Inspectorships under the Local Authorities are generally given to teachers—usually those in the employ of the authority. A certain amount of teaching experience is essential.

The position and salary of an inspector is about on a par with that of a secondary school head teacher. Inspectors under the L.C.C. receive from £250 to £800 a year. School attendance officers, £80 a year.

Two scholastic movements in particular stand out very clearly before the observer of the present day. One is the improving social position and increasing salary of teachers in every grade; the other is the growing popularity among teachers of a training college course, and the increasing number of trained teachers in the profession. It is impossible to resist the conclusion that there is some connection between the two tendencies.

Future Prospects. In the past, the schoolmaster has been commonly looked upon as a failure. He has received the miserable wage of a man who has failed in life; and this attitude of the public was too often justified by the facts. The scholastic profession has suffered in the past, and still suffers in a less degree from being the dumping ground of able men with no definite aim or purpose in life. The existence of these men, unfitted by special training for any serious profession, has been dangerous and detrimental to the teacher who took his work seriously, no less than to the pupil whose education was imperilled through the incompetence of such men—good scholars though they might be—either to teach or to maintain discipline.

It is at last being recognised by the public that a teacher's vocation is a high one: that he is a labourer worthy, not only of better hire than he has generally received, but of the respect of all his fellow workers in whatever field. But the teacher must remember that the maintenance of this respect depends on himself. The public take a man, and his work, at his own valuation, and the teacher can claim the respect of this generation only so long as he does his duty to the next, entering the scholastic profession not merely to earn a living, but with a full sense of his high calling and a set purpose to raise and educate mankind in the pupils committed to his charge.

SECRETARIES

Private Secretaries. The profession of a private secretary may be classed as scholastic, not so much because his duties are educative—though more private secretaries than one are engaged, either tacitly or overtly, in the education of their chiefs—as because no particular technical training is required for the secretarial life. There is no one branch of knowledge in which the private secretary must excel, yet he should be in some sense acquainted with them all. The berth is pre-eminently one for a man with good general education and some knowledge of the world. It is one into which some men drift almost by accident, to remain there all their lives; while others use it as a stepping stone towards a more satisfactory position.

The Amanuensis. Broadly speaking, there are two classes of secretaries. The first is essentially a letter writer, a very necessary adjunct to every wealthy man much occupied with affairs; the second is an incidental luxury in literary and political life. The duties of a secretary of the first class are in many cases heavy, and the pay, except for rare and fortunate individuals, low. Such a secretary is, in fact, a clerk of more or less skill and responsibility; he has a clerk's duties, a clerk's position, and rather less than most clerks' prospect of promotion.

Still, if a man can be satisfied, for a time at least, with an income of £100 to £150 a year, he may do worse than become a clerical private secretary. There is always a chance of impressing his chief with his ability and character, and so securing transfer to a more responsible post.

Qualifications and Position. The qualifications required by a secretary of this class are substantially those of a clerk in a City office. He must have some knowledge of typewriting and shorthand, a presentable appearance, and sufficient acquaintance with the English language to be able to write a good letter. Above all, he must be able to produce evidence of high character, and must show himself possessed of common-sense. His employer wishes to be relieved of responsibility in the smaller matters of everyday life; and a secretary who can be trusted to look after things intelligently on his own account becomes indispensable to a busy man. He can make his own terms

On the other hand, a secretary of this class must be at the beck and call of his master. Not infrequently he lives in the house, and is hardly free from duties, morning, noon, or night; no Factory Act applies to his employment, and no code defines his social position. Altogether it is a strenuous life, and a poorly paid one.

The Political Secretary. But the position of a secretary of the second class is very different, and far more satisfactory. To begin with, he is a luxury, and the market for luxuries is somewhat inflated at present. If he be wise, he knows himself a luxury; but if he be skilful, his master thinks him a necessary.

The salary of such a secretary is from £200 to £500 a year, and his social position is not so far off his chief's. Many parliamentary private secretaries are less the servants of their immediate employers than apprentices to the game of politics, just as the editor's private secretary is an apprentice to journalism.

Posts of this class, however, are not so easily found as the ones before described. A luxury is expected to be a highly-finished article. Generally a parliamentary secretary is an Oxford or Cambridge man, though some of the most successful ones have not been through the university. But whatever his training, the qualifications of such a secretary are varied and peculiar.

Lord Brougham said once that the King knows as much law as his chancellor, but the chancellor knows where to find it. Even so the secretary—facts and figures, books and blotting-paper, he must know where to lay his finger on them all. Beyond this, unless he writes letters, which many do not, he holds something of a sinecure, and that not ill-paid.

To the average educated man, no training could be more valuable than a year or two as private secretary to some prominent M.P. He meets many important people; he appears occasionally on his chief's platform, and learns to face an audience without quailing. When duties press heavily on the Member, the secretary may be charged to make notes for a speech in the House, and so take a turn himself at the helm of the vessel of State.

And the field is an open one. Some posts, of course, go through influence, but the central party agent can always find a berth for a man who impresses him favourably.

SCHOLASTIC PROFESSIONS *concluded; followed by* THE CHURCH

PHOTO-ENGRAVING

How Line and Half-tone Blocks are Made. Photo-lithography Reproduction in Colours. Collotype and Photogravure

ENGRAVING continued from page 6291

By P. G. KONODY

THE term "Photo-engraving" comprises all methods of reproduction for printing in which photography takes the part of the artist in the older and more costly processes, such as engraving on wood and steel, or drawing on stone. The various methods used for the production of newspapers, books, picture postcards, etc., can be classified as follows: (1) Line process; (2) half-tone process; (3) photo-lithography; (4) three-colour process; (5) collotype; (6) photogravure.

Making Line Blocks. The first of these is the most simple. It is used for the reproduction of pen and ink sketches, and such prints or drawings as contain only black and white, with no intermediate half-tones. The original print is put on a copying board in front of a camera, and a negative is made in the ordinary way [see PHOTOGRAPHY]. In making a line negative, it is necessary that the lines should be perfectly transparent, and the background as dense as possible. For this purpose, the old-fashioned collodion, or wet plate process is recommended, as it gives crisper and sharper lines than dry plates do, owing to the thickness of the gelatin in the latter. Collodion is prepared by dissolving pyroxylin (guncotton) in a mixture of ether and alcohol, the proportion of which is governed by the weather (about 200 grammes of pyroxylin, 20 grammes of ether, and 20 grammes of alcohol). In summer, for instance, more ether will have to be used, as it evaporates very quickly. To this solution is added a quantity of iodide and bromide salts (about 70 grammes ammonium iodide, 25 grammes of cadmium bromide and about 20 grammes calcium chloride). The collodion thus prepared should be allowed to ripen for a few days. It can be obtained ready mixed.

Sensitising and Developing Collodion. A glass plate is then carefully cleaned by immersing in weak nitric acid, and polishing after drying with a chamois leather and a paste of prepared chalk and methylated spirit. The edges are coated with indiarubber dissolved in benzol, to prevent the film peeling off. The collodion is then poured on to the plate, drained off at one corner, and gently moved about to allow the ether and alcohol to evaporate [1]. Whilst still slightly moist, the plate is immersed in what is called the silver bath, a solution of nitrate of silver in water, to which a few grains of nitric acid and iodide of potash have been added. As this makes the collodion sensitive to light, it is essential that this operation should be carried on in the dark-room. The silver bath should also be kept covered.

The exposure is regulated by the nature of the original; thus, under-exposure will cause the lines to spread, whilst over-exposure will cover them up, so that it will be impossible to get a clear print of the negative. After exposure, the plate is developed with a protosulphate of iron solution in water, of which the following is a formula: 64 oz. water, 4 oz. iron sulphate, 4 oz. acetic acid, 1 oz. to 4 oz. alcohol. Methylated spirit has been added to make the developer flow over the plate, as the latter is rather greasy and repels water. Acetic acid is also contained in the developer; it clears the image and prevents scum forming on the surface. After washing, the plate is fixed with cyanide of potash or hyposulphite of soda.

Intensifying and Printing. To make the background denser, the negative is intensified by immersing it in perchloride of mercury solution, and blackening it afterwards with ammonia if the lines are delicate. If they are fairly coarse, a solution of equal parts of bromide of potash and sulphate of copper in water can be used, and after washing, nitrate of silver solution. This intensifier is more powerful than the previous one, and gives the operator a better chance of rectifying mistakes. A solution of iodine and iodide of potash is now poured over the plate, which is washed and then cleared with weak cyanide of potash. This is the time to remedy slight imperfections, either in the preparation of the plate, or in the exposure. The plate is then blackened with hyposulphite of ammonia or sulphide of sodium.

The negative taken in this way is printed on a metal plate which has been carefully cleaned with pumice powder. Before this is done, another point has to be considered. The print on the metal itself would be exactly like the original drawing, consequently a print off this plate would be reversed on the paper, like an image seen in a mirror. To avoid this, the film either has to be stripped off the glass plate, reversed, and put on to another glass [this is described under COLLOTYPE], or the picture has to be photographed in the first instance through a prism, or by means of a silver mirror, which can be attached to the camera in front of the lens at an angle of 45° to it. It may also here be added that, though daylight can be used in exposing the negatives, or printing on metal, electric light is used by all the photo-engraving houses, as it is less subject to variation.

Printing on the Block Plate. We now come back to the metal plate, which is sensitised by a solution of potassium or ammonium bichromate in water, to which white of egg has been added (1 egg to 5 oz. of water, 10 grammes potassium bichromate, and a few drops of liquid ammonia). The plate is fixed on to a whirler, coated twice, and dried over a gas stove [2]. It is then exposed behind the negative in a printing frame, just as a piece of silver paper would be in ordinary photography. A few minutes are sufficient to make the albumen and bichromate on the exposed parts insoluble in water. The plate is then rolled up with a stiff, fatty ink which has been thinned by means of a volatile oil, such as oil of lavender. After letting the oil evaporate, the metal is put into cold water, and the surface gently rubbed with cotton-wool. This takes off the unexposed bichromate and also the ink adhering to it, and only leaves the coating and ink on the exposed parts—that is, the lines of the picture. The plate is now dried and covered with powdered bitumen, which sticks to the greasy ink and is dusted off

the plain parts with a camel hair brush. It is heated until the bitumen melts and forms a protection for the picture against acid.

Etching and Finishing the Line Block. The plate is now ready for etching, but before it is put into the acid trough, the margin, back, and large open spaces in the picture should be covered up with shellac dissolved in methylated spirit, so that no acid need be wasted in etching metal which can be cut away quickly enough by machinery afterwards. For etching, the plate is put into an earthenware trough containing weak nitric acid, and gently rocked. After a little while it is taken out, and the acid-resisting surface strengthened by means of soft litho ink, with which it is rolled up; a soft nap roller is best used for this purpose. The plate is then dusted in with dragon's blood or bitumen and carefully brushed in four directions.

Rinsing under the tap will remove any particles of dust on the plain zinc, leaving only those that have stuck to the soft ink. The latter spreads slightly over the edges in the subsequent heating over a gas stove, and thus prevents the acid underbiting the lines. Care should be taken not to overheat the plate, as it will make the ink run too much. This process is repeated until the plate is etched deep enough—that is to say, till the lines stand out sufficiently from the ground to print well on the letterpress machine. All ink is then washed off with hot potash or turpentine and the plate rolled up again, this time with a very stiff ink and a glazed roller. This is done to get rid of the shoulder which has formed in getting the depth. One or two of these finishing baths are generally sufficient if the plate has been etched well. When all the shoulder has disappeared, the plate is cleaned again, the shellac scraped off the back, and the block is ready to be mounted. For this purpose all metal forming the margin or open spaces in the picture itself is cut away either by a fret saw or a routing machine, and the plate is tacked on to a piece of oak or mahogany which is afterwards planed down to the exact height of type—that is, nearly $\frac{11}{12}$th of an inch. The block is now finished. Ground tints are laid on line blocks by mechanical means before etching to give shading to them [**3**].

Half-tone Blocks. The next process, called half-tone, is much more complicated. It is used for pictures which have no sharp and black-and-white outlines, but a variety of tones more or less gradually blended into one another, which cannot, therefore, be reproduced by line. As the machine will only print a level surface, it is necessary to produce a block, the surface of which, whilst perfectly level, must be regulated so that light and shade are expressed by a kind of grain in relief, which is very close in the shadows, and opens up as it gets lighter in tone. The simplest way to produce such a grain is to photograph it at the same time as the picture. For this purpose there are on the market so-called "screens," which are produced by ruling lines diagonally on glass plates, then filling these lines up with lampblack, and placing two such plates together, to form a net. When photographed a short distance behind this screen, the negative will show the picture itself, cut up all over by a net which varies in strength, according to the nature of the image. Thus, on the negative the darkest parts will show a strong transparent net with tiny solid dots in the centre. This net gets thinner as the tones go lighter, till in the highest lights only transparent dots will remain in a solid net. The fineness of the grain itself is varied according to the nature of the work. For poster work, for instance, the screen will contain about 25 lines to the inch; for newspaper advertising a 50 screen is commonly used; most of the SELF-EDUCATOR illustrations are printed from blocks with 110 lines to the inch; whilst for finest bookwork 400 can be used. A photograph of aerated-water syrup tanks is reproduced in **4** in four different screens.

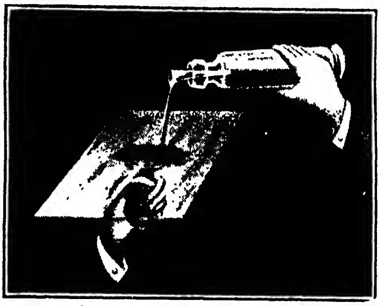
Exposure Through the Screen. Great care has to be taken to give the plate exactly the right exposure to light. It is best to use square diaphragms, or others with extended corners, as these give a square dot in the tones, which etches better on the metal than a round dot. It is also advisable to flash a white card in front of the picture for a few seconds, to give more body to the dots in the dark parts. It is not advisable to have the latter too black, as too much detail is lost that way. The negative is then developed, fixed, and intensified, in the same manner as a line negative. After intensification, when the negative is cleared with weak cyanide of potash, a good photographer can even improve on the original, especially if it be dull and flat, by forcing the shadows a little, or by etching those parts of the negative which lack brilliancy. A good negative should contain fine pinpoint dots in the shadows, a square dot, with extended corners that join on to the next, in the middle tones, and fairly fine, transparent dots in the high lights. If no prism or mirror has been used, the plate is stripped and reversed in the same way as a line negative, and the surface can afterwards be protected by albumen, gum, or thin gelatin solution poured over it; then it is drained and dried.

Sensitising and Etching the Half-tone Plate. The sensitising solution for the metal plate consists of fish glue, ammonium bichromate and water; sometimes ammonia or white of egg is added. (Formula: 1 oz. clarified fish glue, 2 oz. water, 30 gr. ammonium bichromate.) The copper or zinc is cleaned very carefully with pumice powder or charcoal, coated, and put on a whirler. It is then turned slowly over a covered gas flame till the coating is perfectly dry, and exposed behind the negative for a few minutes. Then it is taken out and put into cold water, which dissolves the fish glue and bichromate where not exposed to the light. To show more clearly what the result is like, the plate is put into a solution of some aniline dye, which shows up the picture. Under-exposure makes the film come off the metal, whilst over-exposure fills up the dots in the dark parts. If rightly exposed, the plate is rinsed and dried. After this it is held over a gas flame and "burnt in." The image will at first vanish altogether, but gradually reappear, till it has reached a rich reddish brown colour in the darker parts and a silvery bluish tone in the high lights. It is then cooled off, and is ready for etching. If a black line is wanted round the picture, it can now be drawn with thin litho ink.

For etching, the plate is shellacked at the back for protection. Copper plates are etched with perchloride of iron at about 40° Beaumé; zinc plates in a weak bath of nitric acid, with some pyroligneous acid and sal ammoniac added (Formula: 5 oz. water, 6 oz. nitric acid, 1 oz. sal ammoniac, 1 oz. pyroligneous acid), to counteract the action of salts formed by the lead, etc., always contained in commercial zinc. The plate is left in this bath till a sufficient depth is reached, and the darker parts begin to open up. It is then taken out and proved on a hand press. If it is found that some parts require more etching, those that have had sufficient are covered up with litho ink, and the process repeated until no more etching is necessary.

Any spot or faults are then engraved by hand, and the plate is ready for mounting, as described above.

Photo-lithography. Photo-lithography is really a part of the half-tone process. In the ordinary way a print from a half-tone block can be made on a special transfer paper with litho ink, and then transferred on to the stone. It is, however, quicker and less costly to make a print direct from the line or half-tone negative. The half-tone negative made for this purpose must be stronger in contrast than the negative for half-tone process on metal, as no subsequent etching is possible on the stone. The line negative need not be altered. Neither must be reversed, as they are not printed on the stone direct, but on paper first, which reverses them on to the stone. The transfer paper, which has a gelatin or albumen surface, is immersed in a solution of bichromate of ammonia, and then dried. It is exposed behind the negative in the usual way, and then rolled up and developed exactly like a line plate. When dry it is ready for transferring to the stone.



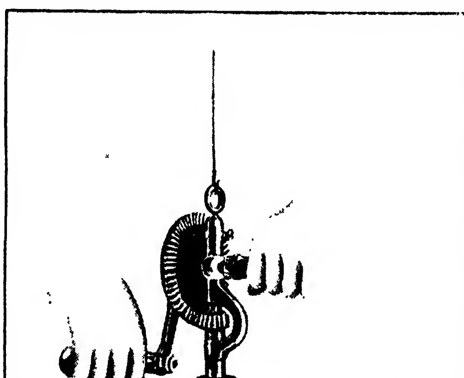
1. COLLODION COATING
Pneumatic negative holder

The Physical Basis of Three-colour Work. The next process, called three-colour work, is also a half-tone process, but, as the name indicates, has for its object reproduction in colours instead of in black and white only. Before going into the process itself, it will be necessary to explain a few things about light and colours in general [see PHYSICS, page 2431]. According to the now universally accepted theory, light is the vibration of the ether. A luminous body sends out waves of light in all directions, waves of different length striking the eye as differently coloured light. By being struck simultaneously by waves of different length, the retina receives the impression of white light, which is no single colour, but a mixture of colours. In the same way, if one series of rays be removed, the rest will strike us as one colour only.

All the spectral rays need not, however, be contained in the white light, as a suitable choice of two will give the same impression. These are called *complementary* colours — as, for instance, red and blue-green, orange and cyan-blue, etc. According to Young's theory there are only three kinds of nerve fibres in our eyes sensitive to light, and these communicate to us the primary sensations of red, green, and violet. These three colours are, therefore, called the fundamental colours. If all the three nerves are acted on simultaneously by light rays, we see white.

Pigments absorb colour rays. Now we must distinguish from light-emitting substances those which only reflect or absorb certain rays. Some absorb parts only, and reflect others, which combine together in a colour mixture, and thus give us the impression of colour. Substances, either in a solution or a powder, that absorb certain rays in a high degree are called pigments or dyes. To distinguish them it is necessary to keep in mind that a colour ray emits light, whilst a dyestuff only reflects borrowed rays.

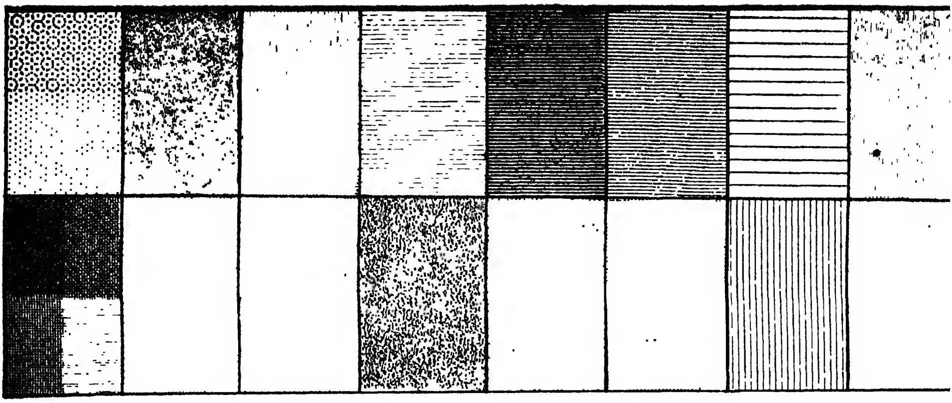
The Principles of the Process. For commercial purposes it is essential that a colour reproduction should be made with as few printings as possible to avoid expense; and it has been found that by mixing three pigments nearly all colours can be reproduced. These printing inks must be very pure and also fairly permanent if exposed to light. It will suffice here to say that the inks adopted are a yellow, red, and blue, which are a compromise between the various conditions.



2. WHIRLER AND STOVE

The next thing is to produce negatives to correspond with these inks. They must show no action of light in those parts where the colour of the original corresponds with the ink, and the shades arrived at by blending this colour with the other two primary colours must be represented by gradations in the negative governed by this first colour. We must, therefore, exclude light rays of the particular colour which must be transparent in the negative, and only let those rays act on the plate which are absent in the reflected light of the pigment. Thus, for the red negative the plate must be sensitive to green, and equally for the yellow and blue negatives the plates must be sensitive to their respective complementary rays. To exclude light not wanted we have to employ so-called light filters. These consist of tanks from $\frac{1}{16}$ in. to $\frac{3}{8}$ in. wide, which are filled with aniline dyes in solution. The correctness of these dyes is tested with the spectrum. They have to correspond with the light-sensitive qualities of the plates used.

Dry and Emulsion Negatives. The negatives can be made with dry plates or emulsion.



3 VARIOUS TINTS USED FOR GROUNDS OF BLOCKS

For the former there are various brands of plates on the market specially prepared for the purpose. For the latter, Dr. Albert's emulsion is now generally used. It may be added here that though the latter gives much better results it requires great cleanliness, and cannot be worked in the same room, or dark slide and camera, as the collodion process, as any free nitrate of silver upsets the emulsion. There are days when the emulsion cannot be worked at all, and as its composition is a secret, it is almost impossible to find a remedy for an unknown cause.

The first negative to be made is the one for the yellow print. Any ordinary dry plate will do for this, as it is not sensitive to yellow, while the lack of red sensitiveness is partly compensated by the ultra-violet sensitive qualities of the plate. For this reason no filter is necessary to exclude yellow rays. A tank containing Höchster new blue 1 : 5,000, or a dry gelatin filter can, however, be used if the exposure is very long; otherwise the filter is merely filled with ordinary water.

A set of dry filters can be procured at any house supplying materials for photo-engraving; but liquid filters are preferable, as they can be regulated very easily if they are not quite true. The best position for them is directly behind the lens. As they deflect light it is best to focus the original after they have been inserted. Plain emulsion, with a standard glycin developer (1½ minutes' development), or ordinary collodion, can also be used for the yellow plate. The emulsion process corresponds with wet plate in every detail, except that the silver bath is left out, the plate being sensitive to light without it. The coating has to be done in the dark, where the emulsion itself must also be kept.

The Negatives for the Red Printing. For the second negative, for red printing, a plate is coated with emulsion, as before, but afterwards sensitised with sensitiser "A" (diluted 1 : 10), by floating it over the plate twice; or it can be mixed with the emulsion (1 : 10). For this purpose it is gradually added in small quantities, and shaken vigorously after each addition. Sensitised emulsion must be kept cool, and well shaken before coating. It must, however, be used up quickly, as it will not keep long, and increases in speed as it gets older. As the plate is very sensitive to light, only dark-red light may be used in the dark-room. Before developing, the plate must be well washed under the tap. The filter used is picric acid, about 1 : 1,000, or a corresponding dry filter. For gelatin plates, either orthochromatic or panchromatic plates can be used. Acid green and bichromate of potash solution serve as filter, or a dry filter can be used.

The Negative for the Blue. For the third negative, for blue printing, emulsion is used, mixed with "C" sensitiser in proportion 1 : 40. This is best worked in complete darkness, or with very dark green light. The plate must be washed before exposure. This emulsion will keep in the sensitised state. A mixture of 6 parts Biebrich's scarlet (1 : 1,000) and 10 parts aurantia (1 : 1,000), serves as filter. The same filter will do for red-sensitive or panchromatic dry plates. It is possible to get plates highly sensitive to colour by taking ordinary dry plates, and sensitising them with essine, silver cyanine, etc.; but the beginner will have sufficient difficulties with ordinary plates, or with emulsion without experimenting any further.

Another point which has to be taken into consideration is that if the angle of the half-tone screen is the same in each negative, a very peculiar effect will be given to the finished block, for the three grains will form what is called a Scotch plaid pattern. This difficulty is overcome by using two screens—one ruled at 45°, the other at 105°. For the third plate, the second screen is reversed, giving the angle of 30°. As the cost of screens is considerable, a circular screen has been constructed, which can be turned to any angle required, and thus the expense of a second screen is obviated.

The ratio of the exposure for the three plates is about 1 : 2 : 8, but varies considerably according to the original. The etching, etc., is exactly as in ordinary half-tone process, but, of course, after the first etch, a rough proof in three colours has to be made, to judge whether, and how much, further etching is necessary. With emulsion it is necessary to flash white card for the dark parts, as in half-tone process. This is not done with dry plates.

Collotype Reproduction. This is a purely photographic process, based on the fact that bichromated gelatin not only becomes insoluble when exposed to light, but also retains greasy ink which it otherwise repels. The grain necessary for the gradations of the tones is caused by the reticulation of the film itself.

In the first place a negative is procured either by dry plate or collodion process. If not taken through a prism or from a mirror, it must be reversed. This is very simple with collodion. The film is cut round, the negative put in water, and a piece of paper squeegeed on. The film comes off the glass easily, and is transferred to another sheet, and then back to a clean glass. Should the film be

too weak to stand this operation, it is first coated with a solution of Para rubber in benzol; then, after drying, with ordinary fairly thick collodion. Dry plates give more trouble to reverse, as the film does not come off the glass easily, and stretches considerably. To avoid this, the gelatin must be hardened with alum or formic acid. To make it leave the glass, it is soaked in a mixture of hydrofluoric, acetic, and citric acids, to which glycerin has been added. Instead of glass, the film can be reversed on to celluloid sheets, which, besides other advantages, are lighter, and take up less room.

Preparing the Collotype Negative. The negative is then marked off with strips of very thin tinfoil about an inch wide. This is best done on a retouching desk, where the picture is carefully squared up with pencil on the film side, and the tinfoil stuck on. The latter must be the very thinnest to ensure contact when printing. That the edges must be absolutely square and sharp is obvious. The negative itself must be full of detail and very soft.

The next thing is to get a suitable support for the gelatin, from which the negative is to be printed on the machine. For this purpose, either glass or metal plates can be used. If glass is taken, one side of it must be carefully grained to give the film sufficient grip. This is done by putting emery paste between two glasses and moving them about gently till an even grain is arrived at. It should be neither too fine nor too coarse. The plate itself must be about ½ in. thick, to avoid breakages, and the edges should be bevelled, as they might otherwise cut the inking rollers in the machine. Copper, zinc, or aluminium can also be used. Zinc is cleaned with emery powder and a brush, and then passed in a weak nitric acid and alum bath. (Formula: 60 minims nitric acid, 1 quart water, and 1 oz. alum.) Copper is ground like a glass plate, and aluminium is treated with weak sulphuric acid (1 : 31) or with a strong potash bath. Glass, before being coated, has to have a substratum of albumen and potassium silicate. (Formula: 7½ parts albumen, 3¼ parts of potassium silicate, and 9 parts of water.) Instead of the albumen, stale beer may be used. The mixture is well beaten up and filtered, and after dusting the plate, is poured on, drained off, and dried. The plate is then washed to remove superfluous silicate, and dried again. Before coating, the plates are evenly heated to about 120°, great care being taken to prevent them from sweating. This is best done in a drying oven on a levelling tripod, where the plates are also dried after coating.

Coating the Plate. The solution consists of gelatin or isinglass, some bichromate salt, ammonia, chromic alum and water. The gelatin should be fairly hard, as this gives the plate a longer life on the machine, though it gives more trouble in etching. Both bichromate of potash and ammonia are used. The proportion of the two is ruled by the fact that the former is slower than the latter. A plate coated with the two gives more detail in the dark parts, and more definition than if one salt only is used. The proportion of the bichromate to the gelatin is defined by the salts crystallising out, if in excess. The proportion of gelatin to water is about 1:10, and a little chromic alum is added to avoid excessive relief. The gelatin is first swelled in cold water, and the salts used are dissolved in another vessel. The gelatin is then heated, but not more than from 120° F. to 140° F., and the salts are gradually poured in and stirred. The solution is then filtered through chamois leather, if possible by a filter pump. The solution must be kept warm during the filtering and coating. The plate is fixed on a tripod and warmed, as previously described, and the liquid poured on. It may be guided a little with a clean glass rod to spread it evenly over the plate, and the utmost precaution must be taken that no bubbles or particles of dust remain.

Drying and Exposing. After coating, the plate is dried at about 120°. This takes about two hours. During and after this time it must be kept in the dark, as, once exposed, the action of the light continues and spoils the plate. When dry, the plate should be perfectly even and matt. If glossy, it shows that the gelatin was too cold. Any vibration or cold draught during drying will be shown by wavy or streaky marks. The plate is exposed to light in frames, exactly as in half-tone process, and if several negatives have been stripped on to one plate, they can all be printed at the same time. All waste space between pictures has, of course, to be masked with tinfoil. For exposure, it is best to use an actinometer. If glass plates are used, an additional short exposure to the plate from the back is advisable, as this gives the film more hold on the glass and prevents excessive relief of the picture.

The plate is then washed in cold water, till all unexposed bichromate is removed. This takes about two hours. The subsequent drying also takes a few hours, but at least a day should be allowed to pass before the plate is put on the machine, to give the gelatin time to harden.

4. HALF-TONE SCREENS; RESPECTIVELY 50, 80, 110 AND 150 GRAINS PER INCH

The So-called "Etch." The plate is then put into a bath of water, glycerin, and salt, ammonia being sometimes used instead of the latter. The object is to make the plate absorb moisture. This is called an "etch" (though it is nothing of the kind). It is done to enable those parts which have been exposed least, and which, therefore, absorb more water, to retain the smallest quantity of fatty ink in the printing, whilst the fully exposed parts hardly absorb any water, and therefore retain nearly all the ink. After about half-an-hour, the plate is taken out and wiped with a sponge and dabbed with a clean rag to dry it. The ink used must be very stiff, only thinned down with a little varnish. It is rolled up very carefully with a map roller till the plate, which will not take any ink at first, looks black all over. It is then rolled with a composition roller, which cleans it up, and is now put into the press. An albion, lithographic, or even a letter-copying press will do. It is best to put a few sheets of paper under the plate to prevent breaking, and to back the proof sheet with blotting paper. If on the proof the shadows are filled up, and the high lights are dirty, the plate is cleaned with turpentine, and re-etched. This is repeated several times until a satisfactory result is obtained.

Skies or dirty margins are cleaned up by etching the plate with a weak cyanide of potash, or a strong hypo solution, on a brush. If the plate is wanting in contrast, an etch is given without cleaning the ink off. For a short run, the plate margins can be masked with oiled paper instead of being etched with cyanide. When a proof shows a satisfactory result, the plate is ready to be put on the machine.

The Art of Photogravure. Photogravure is an intaglio process—that is to say, the surface of the plate does not represent the picture, as in all the other processes, but when the plate is inked in, the surface itself is wiped clean, and the picture is produced by the paper being pressed into the crevices to pick up the ink. The process of producing the plate is not complicated, but requires great skill in the final stages, and a good deal of artistic sense and judgment.

In the first place an ordinary negative is made from the original, and from this a transparency either on a dry plate by contact (and if another size is wanted, in the camera), or on a pigment paper. For the latter purpose, a so-called autogravure tissue is procured. Of the two kinds, it is better to procure the one not sensitive to light, as the other does not keep. Before use, it is sensitised in a bath of bichromate of potash and water with a little ammonia added, for about three minutes. A piece of plate glass is then carefully cleaned, rubbed over with French chalk, coated with plain collodion, and the tissue squeegeed on to it. This must be dried in the dark, for, when tissue is once exposed to light, the process of making the gelatin insoluble continues. The negative is then safe-edged—that is, all the edges of the picture are covered with strips of black paper or black varnish.

Another glass plate is then cleaned, coated with bichromated gelatin, and, after drying, exposed to light, to make the gelatin insoluble in hot water. This is to serve as support to the tissue during and after development. The tissue is then exposed to light behind the negative, and as this carbon process cannot be watched, an actinometer must be used with a piece of P.O.P. First the speed of the tissue (which varies according to the make) will have to be tested by comparing it with silver paper which is exposed simultaneously.

After exposure, the paper is put into cold water till it loses all tendency to curl. It is then squeegeed on to the gelatinised plate, and after standing for a few minutes, is developed in water at about 120° F. The backing paper will then come off easily. The water is now renewed, and the picture can be dried as soon as it has been well developed and all soluble matter removed. Under or over-exposed plates will be useless, as all the detail must be clearly defined both in the high lights and shadows.

The copper plate is now dusted in with finely powdered bitumen. This is done in a so-called "dusting box" containing a fan, which violently whirls up the dust. The copper plate, carefully cleaned with whiting and ammonia, is introduced in the centre on a large board, and the dust is allowed to settle. The longer the plate is left in the box, the finer and closer the grain will be. The time is from five to ten minutes. The plate is now heated, and the bitumen melted on. If the graining is not sufficient, the plate can be put back into the box again, and the process repeated.

Finishing and Etching the Plate. For the next stage, a special autogravure carbon tissue is prepared as the one before, except that the glass plate must not be collodionised. It is exposed behind the transparency, the latter having been safe-edged previously. After exposure, it is taken out, immersed in water, and rubbed gently with a sponge to let the water soak in evenly. The copper plate is also sponged and the tissue squeegeed on to it, and then weighted, after backing it with blotting paper. It is developed as before and is ready for etching, the margins having previously been dried and varnished.

The solution for etching consists of perchloride of iron in water, the perchloride having been neutralised with ferric oxide while hot. There should be five baths, varying in strength from 45° to 32° Beaumé. These baths can be used over and over again, as they improve with use. They will have to be tested occasionally for strength. The plate is first put into the weakest solution (45° Beaumé), where it remains till the copper under the shadows discolours (about one minute). The next two solutions, which attack the half-tones, take about one and a half minutes, while the final baths take from two to three minutes respectively. The plate should be etched one minute after the highest lights have been attacked. Finally the plate is cleaned with carbonate of soda, the film rubbed off, and the margins cleaned with benzol, and brightened up with weak caustic potash and very weak sulphuric acid. When the plate is quite finished, defects can be remedied by rouletting and burnishing. After this, the plate is steel-faced and is ready for proving.

Classes and Books. Classes in the above processes are held at the Polytechnic, Regent Street, and the Bolt Court School of Engraving, Bolt Court, Fleet Street, London, as well as in similar institutes all over the country. Useful books on these subjects are: "Half-tone Process," by J. Verfasser; "Collotype Process," by W. Fithian; "Three-colour Process," by A. v. Hübl; "Photogravure," by W. T. Wilkinson; "Manual of Photo-engraving," by H. Jenkins, 1902 (Inland Printer Co., Chicago); "Photo-mechanical Processes," by W. T. Wilkinson (Hampton & Co.); "Collotype and Photo-lithography," by Dr. J. Schrauss, translated by E. C. Middleton (Iliffe & Son); "Photo-lithography," by G. Fritz, translated by E. J. Wall, 1895 (Dawbarn and Ward).

Continued

FAVOURITE GARDEN FLOWERS

The Queen of Flowers. Lilies, Chrysanthemums, and Carnations. Bulbs of Spring and Autumn. Dwarf and Bedding Plants and Flowers. Ferns

By H. HAVART

NO matter in what part of the kingdom a young gardener may find himself, he is sure to be called upon to pay special attention to the five favourite garden flowers: the rose, lily, chrysanthemum, carnation, and sweet pea. There are, of course, many other favourite garden flowers, and details of their culture are given in this and further articles.

The Culture of the Rose. The rose has often justly been called the "Queen of Flowers," and it is well to remember that her Majesty requires regal treatment. Failure with roses is generally due to the fact that they are planted in the wrong sort of soil. It is impossible to get good roses in bad ground, and, where the soil is not suitable for their cultivation, it must be taken away, and proper material introduced. The soil in which the rose thrives best is a good rich loam two or three feet in depth, resting on a subsoil of clay. The clay subsoil, being impermeable, retains all moisture, and so keeps the roots of the roses cool during the hot months of summer. Where the soil is very light it must be made heavier by the addition of thick, heavy loam and clay, otherwise the gardener is merely courting failure. Roses are generally grown in the forms of "Standards," "Dwarf Standards," "Bushes," or "Climbers."

A standard is a rose which has been grafted on to a stem about three feet in height. A dwarf standard has been grafted at about half that distance, while a bush usually springs from the ground without showing any main stem at all, having been grafted close to the roots. Roses on their own roots—that is to say, roses that have not been grafted at all—are invariably grown as bushes.

Roses are usually grown as standards when extra large-sized blooms are required for exhibition purposes, or where space is limited. In places where plenty of room is available there is no doubt that the best way to grow the rose is in its bush form, as it blooms far more freely under these conditions.

The Best Varieties of Roses. Roses are divided into several sections, or groups, the most important of which are: Teas, Hybrid Perpetuals, Noisettes, Hybrid Teas, Bourbons, Monthly roses, and Ayrshires, titles which are derived chiefly from the land of their birth, or the time of flowering. Altogether there are nearly two thousand varieties in cultivation, and the number is added to every year.

The following twenty-four sorts recommended by "The Century Book of Gardening" as suitable for town and suburban culture are, perhaps, as judicious a selection as could be made for all purposes:

Red: General Jacqueminot, Alfred Colomb, Abel Carrière, Dupuy Jamain, Cheshunt Hybrid (climber).

Pink: Mrs. John Laing, Baroness Rothschild, La France, Captain Christy, and Pink Rover (climber).

White: Boule de Neige, Merveille de Lyon, and Aimée Vibert (climber).

Yellow: Marie van Houtte, Madame Hoste, Emily Dupuy (climber), and Medea.

Apricot: Francisca Kruger, Safrano, Rêve d'Or (climber).

Salmon: G. Nabonnand, Bouquet d'Or (climber), Dr. Grill, and Felicité Perpetue' (climber).

How to Propagate Roses. The three chief methods of propagating roses are by grafting, budding, and cuttings. Grafting [19] and budding are usually performed upon the stem of a wild briar whose sturdy growth makes it eminently adapted for the purpose. This briar is called a stock, and the main stem is cut down to the desired height of the standard, or bush, as the case may be. A V-shaped notch is cut in the top of the stock, from one to three inches deep, according to its diameter. The end of the graft (the rose which it is desired to propagate) should be cut wedge-shaped in order to fit the notch in the stock, and carefully inserted, the junction being thickly covered with clay to afford protection. The operation of budding consists in lifting, with a very sharp knife, a bud, and about a quarter of an inch of the bark round it, and inserting it in a stock. The stock is prepared by cutting a T-shaped slash in its bark, raising the bark gently with the knife, so that the bud may be inserted underneath it, and, when once the bud is in position, binding it round fairly tightly at top and bottom, to ensure its retaining its position.

Cuttings are slips taken off with a slanting cut, and containing two or three "eyes." They are best potted up in small pots in a mixture of sand and leaf mould. If put in a frame and well exposed to the sun they will root in about a month, but must be kept free from frost all the winter, and gradually hardened off the following spring.

The operation of pruning roses is carried out in the spring, and is better performed with the secateur than the pruning knife. Climbing roses do not, of course, require so much pruning as the standard or bush sorts. Probably no two rose-trees require exactly the same sort of pruning, but the golden rule to be observed is to see that the branches in the centre are well thinned, so that light and air have free access.

The best time for planting roses is from November to March—the earlier the better. All newly-planted roses should have protection from frost during the winter months. This may be afforded by a mulch of straw, bracken, or similar material.

The Lily. Though not so popular as the rose, perhaps, lilies of varied sorts must be found in profusion in every garden which pretends to be at all representative.

Generally speaking, lilies do not like a heavy soil; consequently, with the exception of a few varieties, the heavy clays which are to be found so frequently in the neighbourhood of large towns and cities are not calculated to grow them to the best advantage. A light rich soil, with plenty of sand and leaf-mould in it, is what the lily revels in, and it is one of the few flowers which has no liking for the presence of animal manure.

The most popular forms of lilies suitable for culture in gardens are given in the table on next page.

The Chrysanthemum. The immense popularity to which the chrysanthemum as an exhibition flower has attained during recent years has militated somewhat against its general employment as a garden plant. In fact, it is not too much

to say that the efforts of most growers have been directed more to producing isolated blooms of gigantic size, than to growing the plant for general effect.

THE MOST POPULAR LILIES		
Name.	Height.	Colour of flower.
Auratum ..	About 6 ft.	White with yellow band
Bulbiferum ..	2 ft. to 3 ft.	Orange red, black spots
Madonna ..	tall, varies	White
Easter	2 ft.	White
Tiger	3 ft.	Red, purple spots
Speciosum rubrum	2 ft. to 3 ft.	White, pink spots, crimson markings
Orange	6 ft.	Orange, black spots
Scarlet Martagon	3 ft.	Bright red
Elegans ..	1 ft. to 2 ft.	Orange

It is a perfectly hardy flower, and may be grown in the garden border with the same facility as the dahlia. Chrysanthemums are apt, certainly, to be damaged by rains and frosts in the late autumn, but they may be protected from this by an awning of some light material, such as waterproof calico. If grown in pots, they are generally transported at the first sign of frost into a cold greenhouse, and left to finish blooming there. This is the method attendant with least risk, and is generally adopted.

Chrysanthemums are divided into three classes: Incurved, Japanese, and Pompon. The incurved variety, as its name implies, has all the petals curving inward, and overlapping, so that it somewhat resembles a flattened ball in shape. In the Japanese variety of chrysanthemum the petals throw themselves about in every direction, so that the flower looks like the head of a mop, earning for it the colloquial name of "ragged chrysanthemum." The Pompon is a dwarf with small, closely petalled flowers, rarely more than two inches in diameter.

Growing Chrysanthemums for Cutting and Exhibition. The best soil in which to grow chrysanthemums is equal parts of loam, leaf mould, sand, and rotten manure. The young plants should be put in about March or April, according to the weather, about three feet apart every way. If they are simply to be grown for the purpose of cutting, there is no need to tamper with them again, except to give them an occasional dose of liquid manure, but if they are destined for show or decorative purposes in pots it is usual to remove many of the buds so that the whole strength of the plant can be concentrated upon two or three blooms, which will necessarily be of gigantic size. Chrysanthemums grown for this purpose, however, are usually cultivated in pots, commencing with a small thumb pot, and re-potting each time into a larger size, until they are finally placed in nine inch pots, which should contain the best loam, with a little finely powdered charcoal. It is necessary to tie chrysanthemums grown for large blooms to sticks, otherwise they will be topheavy, and fall over.

Like so many other flowers which the nurseryman has taken in hand, the chrysanthemum has innumerable varieties. A few of the best for general culture are Soleil d'Octobre (golden yellow), Madame Desgrange (white), Montague (purple crimson), Ryecroft Glory (yellow-shaded bronze), Vivian Morel (pale pink), Madame E. Roger (green). The last-mentioned variety is somewhat of a freak, and would be grown more as a curiosity than for any ornamental value; it is, however, very hardy, as it does well in many parts of London.

The "Buttonhole" Flower. If the carnation were grown for no other purpose, it would always be sure of a prominent place in gardens by reason of its value as a "buttonhole" flower. To be seen at its best in the open garden, however, it should be grown in beds or clumps. A good plan is to grow the bold, self-coloured sorts in beds, and have little clumps here and there, dotted about the borders, of picotees, flakes, and bizarres. These last three terms are the names by which the striped and marked varieties of carnation are known.

Layering Carnations. A rich, loamy soil is necessary for the carnation. This soil must be well drained, and just a little sand mixed with it. The richer the soil the more vigorous the carnation, but on a light soil the plant will never do well. The chief methods of propagation are from seed, and by the operation known as *layering* [22]. Layering is carried out in July or August, when the plant is in full vigour. Select a good strong shoot near the base of the plant, and clean off all the leaves on that shoot with a sharp knife, except half a dozen at the top. Cut half way through the shoot from below in an almost horizontal direction, for a distance of about 2 in., taking care to cut through a joint in the stem on the way. Push the wounded part of the shoot into the ground, which has been previously prepared by having sand mixed with it, and keep it in that position by pegging it down. Special pegs may be procured for this purpose, but a common hairpin answers the purpose admirably.

Carnation seed must be sown in May, in pots or boxes of rich loamy soil. They must be stood in a sheltered spot, and, when the plants show a few leaves, they can be put out in beds of the same material, and left till late autumn. If they have the protection of a frame during winter, many of the young plants will bloom the following season.

Among the best carnations for the open garden are: White: George Macquay, Trojan [20], Alice: Pink: Duchess of York, Asphodel, Endymion, Raby Castle, Ketton Rose: Yellow: Miss Audrey Campbell: Buff: Mrs. Reynolds Hole, Prince of Orange. Scarlet: The Cadi, Isinglass, King Arthur: and Crimson and Dark Red: the old Clove Carnation, Uriah Pike, Mephisto, Boadicea.

The picotee and other fancy varieties of carnation are more numerous even in variety than the good self colours. Six good ones are Cardinal Wolsey, Ladas, Perseus, Dervish, Mrs. Robert Sydenham, and the Czar.

The Sweet Pea. There is probably no more popular annual flower in the garden than the sweet pea, and certainly none which yields a more bountiful supply of bloom for cutting. It may be had in practically every colour from white to what may, by a very slight stretch of imagination, be called a black, and is of the easiest culture. The sweet pea thrives in any ordinary garden soil, and may be sown either in autumn or spring. Seed should be put in the ground 2 in. or 3 in. apart, and at a similar depth. It is customary to attribute failure with sweet peas to the ravages of birds, and certainly they do a great deal of damage. This may be guarded against to a great extent, however, by rolling the seed in red lead before putting it into the ground. When the young plants show themselves, and are likely to be nipped off, the surface soil should be liberally dusted with soot.

Sweet peas are usually seen in gardens trained up bean sticks placed against walls or fences, or in clumps. A method which has recently been put into practice with good effect, is to sow them in rows, a bean stick being driven firmly into the ground at each end of the row. At about 3 in. above the ground, a string is stretched from pole to pole, and the young plants lifted up, so that

their heads rest on the string. As they grow higher and need more support, other strings can be stretched across and so on, until they reach their full height. Practically, the only support to be seen is the pole at each end of the row, and even this may be hidden in a simple way by letting a fast-growing climber, such as the nasturtium, Japanese hop, or canary creeper, run up it. Unless it is desired to save seed of any particular plant for future use, the flowers should never be left on sweet peas until the seed pods form, as this weakens the supply of bloom. On the contrary, the blossoms should be cut almost before they are fully expanded, and then the plants will go on yielding a prolific supply of bloom right through the summer months. As regards sorts, all of those named "Eckford" are good, and there are several of these christened after different members of this famous grower's family. Apart from these, a few of the best are Blanche Burpee (white), Captain of the Blues, Venus (pink), Countess of Radnor (heliotrope), Cardinal (red), and Primrose (pale yellow).

17. A NEW BEDDING PANSY

The Bulbs of Spring. It is impossible to overestimate the value of bulbs in the garden, no matter whether they be the spring or autumn flowering kind. At present, the former are much more generally cultivated than the latter. This has been particularly the case during recent years, now that the custom of naturalising such things as daffodils, crocuses, snowdrops, and anemones, in the grass has arisen.

Hyacinths are grown in pots or glasses. For pot culture, a mixture of ordinary garden soil with sand and a little leaf-mould answers well, or the leaf-mould may be dispensed with if it is not readily available. October is the best month to plant the bulbs, and they should be barely covered with soil. A leading firm of growers says: "After potting, give one good watering, and then place the pots outdoors on a bed of ashes, cover with 6 in. of cocoa fibre, and leave them exposed to all weathers. When the bulbs have well rooted, and made about 1 in. of top growth, they may be removed indoors, first into a subdued light, until the foliage has attained its full green colour, and then in the sunniest situation at command in the greenhouse or conservatory. It is a good plan to place an inverted flower-pot over the young growths for a few days after being removed from the plunging bed, as by so doing they are protected from possible draught. Abundance of air, a moderately moist atmosphere, and plenty of water at the roots, are then necessary for early well-developed flower spikes."

18. PROPAGATING BEGONIAS FROM LEAVES IN A PAN

In quite small suburban houses, hyacinths in glasses are the rule rather than the exception. During the winter it is best to fill the glasses with rain-water to such an extent that the bottom of the bulb just touches the water. At first, keep the glasses in a dark place, filling them up with water as it evaporates; by this means, healthy root growth is promoted. By the time the glasses are nearly full of roots, they may be gradually exposed to the sun in a window. This treatment ensures large and healthy trusses of bloom. Hyacinths which have flowered in pots one year, will flower in a border for several years in succession afterwards, but the resulting flowers will not be so large.

The Narcissus (Daffodil). The daffodil [21] is undoubtedly the most valuable spring-flowering bulb we have in our gardens, and there is no capacity in which it cannot be used. It may be grown by thousands on banks, lawns, and in meadows, increasing enormously, or it will flourish bravely on the sooty window-sill of a city slum. The best way to grow it in pots is to use three bulbs to a five-inch pot. The soil it likes is just ordinary garden soil, with a mixture of sharp sand. As daffodil bulbs vary so much in size a good general plan is to plant the bulb at one and a half times its own depth. After flowering, the bulb should not be lifted out of the ground until the foliage has quite died down; but where this cannot be avoided, owing to the ground being required for other purposes, they should be carefully lifted, and re-planted in some spare corner until the foliage has quite withered.

The narcissus family is divided into several important groups, including the Trumpet section, the Star daffodils, and the Poet's daffodils. They number several hundred varieties, ranging in price from a few shillings per hundred to fifty guineas a bulb.

The Brilliant Tulip. What the daffodil gives us in delicacy of colour the tulip supplies in brilliancy, and it is entitled to rank among the best early flowering bulbs. It is not, however, adapted for culture in the grass, but does well in beds of soil as recommended for the daffodil. The genus is divided into three sections: Early flowering, May flowering (Gesneriana) and late flowering (Darwin). There is also a curious distinct breed called the Parrot Tulip, so named for its peculiar shape and colour. One tulip above all others suitable for town culture is Kaiser's Kroon, a brilliant scarlet tulip with yellow edges; while other good sorts, arranged in order of time of flowering, are: the Duc Van Thol group, Ophir d'Or, Proserpine, White Swan, Bouton d'Or, Gesneriana Spathulata, Golden Crown, Royal White, May Queen, Salmon King, the Bride, and the Sultan, the latter approaching nearest to the much sought after black tulip.

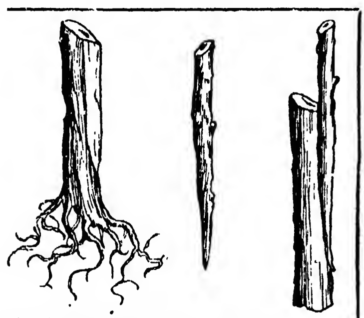
The Iris, Gladiolus, and Lesser Bulbs. Although different varieties of iris may be made to give flowers from the beginning of the year on into August, the great majority of them are spring flowering bulbs. These are what are known as the Spanish and English sections. September is the best month for planting the bulbs, which should be

put in deeply in any ordinary garden soil. There is a long list of sorts of all colours from white to nearly black, and splashed and marked with every conceivable hue. Some choice species of the iris include: Alata (Scorpion iris), Atropurpurea, Iberica, Reticulata, and Unguicularis.

The spring flowering section of gladiolus bulbs is not a large one, only one or two varieties blooming as early as May. As, however, those which do not come into flower until June and July are planted at the same time as the ordinary spring flowering bulbs they are best included here. Gladioluses require shelter from the wind, and also shade from the full heat of the sun. October is the best month to plant, though good results have been obtained with bulbs planted as late as Christmas. A layer of bracken or straw should be spread over them to protect them during the winter, while deep planting, say at a depth of six inches, also effects an insurance against damage by frost. The Bride (pure white) and Byzantinus (light crimson) are the best of this early flowering section.

Crocuses, snowdrops, anemones, scillas, alliums, dog's-tooth violets, chionodoxa, and muscari are the most important of the dwarfer growing spring flowering bulbs. Their culture is exceedingly simple. In fact they merely require putting in the garden or woodland, or wherever it is proposed to grow them, at any time during the months of October or November when the ground is dry. The rule of planting at the depth of a bulb and a half holds good in this case.

Autumn Flowering Bulbs. Just as the spring flowering bulbs are planted in autumn, so should the autumn flowering bulbs be planted in spring. With the exception of the gladiolus, however, the culture of autumn flowering bulbs has been somewhat neglected, though their presence would be a great help at a time when gardeners are apt to rely greatly upon the dahlia and chrysanthemum. It is possible to get exactly the same effect with the crocus in autumn as it is in spring. As a writer in the "County Gentleman" says. "Their culture is simplicity itself. They should be planted in any ordinary garden soil, and just covered with earth, or, if in pots as specimens, in ordinary potting mould. . . . The best autumn flowering crocuses are the Asturicus varieties, which represent the mauves and purples in all shades: Sativus, the purple saffron crocus; Hadriaticus, pure white; Zonatus, rose and orange; and Speciosus, bright blue, recalling, when planted out in the grass, the beauties of the grape hyacinth in the spring."



19 A METHOD OF GRAFTING ROSES.

The autumn flowering gladioluses are varieties of the species known as Gandavensis, and they may be relied upon to provide those brilliant masses of scarlet so often needed but so rarely seen in the autumn garden. It is merely necessary to plant them out in March in decent soil, and leave them to take care of themselves. They are somewhat shy of frost.

The belladonna lily (*Amaryllis belladonna*) is the most beautiful of all the autumn flowering bulbs, but it should only be planted on the south side of a house or wall, as it is not quite hardy in other situations. It grows nearly a yard high, with large lily-like white flowers, tinged with pink towards the centre. It needs deep, fairly rich soil, and if the bulbs are planted in autumn, which is the best time to ensure a display of bloom the following year, they should be protected with a layer of fibre during the winter. They soon establish themselves and will bloom freely every year.

The tiger flower (*tigridia*) should, as far as culture is concerned, be treated the same way as the gladiolus. The flowers are six inches wide, bright red in colour with crimson spots, and the plant attains to a height of 2 ft. or more. Each flower only lasts a day, it is true, but a succession of flowers lasting in all nearly two months are borne on the same stem.

Other autumn flowering bulbs include Crocosmas; Sternbergias (the best authorities say that this is the lily mentioned in the Bible); Leucojum; the autumn flowering Scilla.

The Dwarfer Flowers of the Garden. The proper place for dwarf flowers in the garden is obviously in front. Many of them are of great value for edgings, while others help to form a carpet at the foot of taller growing things.

Although the violet is frequently found wild in the hedgerows and copses of the country, the practice of cultivating it, either for private use or for market purposes, is not a general one. The French grower thinks nothing of having two or even three acres of ground covered with violets, while the English grower is content with a few square yards. As violets like shade, they are essentially suitable for carpet plants, and they thrive in any moderately good soil. It is well not to leave them for more than two years in the same spot, however, as they deteriorate in quality after that time. They are best planted in May for the following season's display, a little manure from the hotbed being forked in when planting. The most popular sorts are Neapolitan, Marie Louise, La France, the Tsar, and Princess of Wales. Belle de Chatenay is one of the best white sorts.

Pansies, Lily of the Valley, and Lobelia. The pansy [17] is a sister of the violet, as both belong to the same genus (Viola). They are one of the easiest garden flowers to grow, and may be used as edgings or to cover the surface of a bed of roses, or other flower. Pansies may be planted either in autumn or spring, the former for early flowering. They should be put in about 9 in. apart. To obtain plants from seed in the open air it should be sown in the middle of summer (say, July), and the little plants transferred to the flowering beds in the ordinary way in the autumn, when they will bloom the following spring. Both the violet and the pansy are subject to attacks from green fly, and, occasionally, red spider.

The lily of the valley is so frequently seen forced in pots in company with other exotics in florists' shops in the middle of winter that the fact that it is a perfectly hardy garden flower is apt to be overlooked. It can be grown almost anywhere, and suburbs near to the smoke of London appear to suit it well. The corms should be planted in October, just at the time when the spring flowering bulb planting is going on, and the bed in which it is proposed to plant them should have a liberal dose of leaf-mould mixed with the surface soil. The corms

should be placed about 3 in. apart, and just covered with soil, and they will start into growth in early spring. It is a good plan to change the position of lily of the valley beds, or, at all events, re-make them, every five years.

The dwarf section of the lobelia family is known technically as *Lobelia Erinus*. It is the familiar little blue flower so often seen as an edging plant in gardens, and also as a prominent feature in window-boxes, for both of which uses it is admirably adapted. The lobelia is only half-hardy, and requires the protection of a greenhouse in winter. The plants can be raised from seed sown in boxes of light soil at Christmas-time, or thereabouts, and given a gentle heat. If the common mistake of sowing the seed too thickly has not been made, they will be ready for putting out in May without further transplantation. Emperor William is one of the best sorts, and White Ladie is a beautiful white kind.

20. BORDER CARNATION (TROJAN)

Virginian Stock, and Other Dwarfs. The Virginian stock is one of the very hardiest of dwarf growing annual flowers, adapted for an edging, and its culture is simplicity itself. It is only necessary to take a stick and go out into the garden on a bright day during April or May, and drag the stick along the edge of a bed or border, so that it leaves a furrow behind it. Into this furrow sprinkle the Virginian stock seed gently, and just cover it with the earth which has been disturbed. In a very few weeks, a substantial edging, from 4 in. to 6 in. in height, will make its appearance covered with thousands of tiny flowers—red, white, or mixed, according to the variety used. One sowing of Virginian stock will bloom for many weeks, and it may be renewed by successive sowings.

The most useful variety of the Alyssum family of dwarf-growing plants is the sweet alyssum, a white, fragrant little flower, useful as an edging, or charming in effect if sown to form a broad sheet, and flowering all through the summer and well on into the autumn. It is best sown in the open air in spring, and if the precaution of sowing thinly is taken there is no need for transplanting.

21. "EMPEROR DAFFODIL
For bed, pot, or window-box

Nemophila is another of the dwarf hardy annuals, and should be treated in the manner already described for this class of flower, with one difference. In addition to sowing in the spring for summer flowering, a sowing should be made in the autumn, where tulips and other of the taller flowering spring bulbs are being planted. The nemophila will then bloom with them in the springtime as a carpet of delicate pale blue or white as the case may be. Nemophilas will flourish in any soil, and so are eminently adapted alike for culture in town or country. The plant should never be used, however, where cats are likely to cause any trouble. For some mysterious reason, cats are particularly fond of this plant, and have been known to travel a long way to get at a garden in which there was a bed of it. As their appreciation takes the form of lying down and rolling over and over in it this naturally means the destruction of everything in the bed.

The garden forget-me-not (*Myosotis dissitiflora*) is probably the most useful of all the dwarfer flowers of the garden, inasmuch as it blooms in spring, and so forms a carpet for the bulbs. Seed may be sown in the autumn at the same time, and in the same beds, as the spring-flowering bulbs are put in, and they will all come up and flower together. The plants are easily propagated by digging them up and dividing the roots during the flowering season, or if they are allowed to remain where they are the seed will ripen, drop off, and sow itself during the late summer months. This is not the forget-me-not of the stream side, about which poets talk so much, the latter being known as *Myosotis palustris*.

Other dwarf flowers of spring are *Arabis alpina*, *Limnanthes Douglasi*, *Saponaria calabrica rosea*, and *Silene pendula*, while the stonecrops are at all times useful, apart from their place in the rock garden, in covering up odd corners. The flowers just mentioned are all hardy annuals and merely require the treatment already set forth for such things.

Carpets of Flowers. Upon few subjects has more wordy warfare been waged than that of carpet bedding. The extreme school of "wild gardeners" execrate it, and there is no doubt that, if carried out to excess, these flat beds made up into carpet-like designs are both dull and uninteresting. The rational gardener, however, will be quick to recognise that there is a place for them in every garden that has any pretensions to size. Carpet beds may be of any shape the designer pleases, but this is usually regulated by the size and shape of the place in which the bed is to be put [see Frontispiece opposite page 6529]. A very good plan is for the gardener to work out designs on paper, drawing them to scale, during the long winter evenings. A good idea of what the general effect will be like may be obtained by colouring these plans as near as possible to the hue of the plants it is intended to employ. Before proceeding to cut out the bed it is best to mark an outline of it in whitewash.

The majority of carpet-bedding plants are raised from seed, sown in boxes in March, and subjected to a bottom heat of about 80°. One of the most important plants for carpet bedding is the alternanthera, of which several varieties are useful. They range in colour from yellow to brownish-red, the variety aurea being a brilliant yellow. The pyrethrums, or golden feathers, are another mainstay of the carpet bedder, and the different varieties give him grey, pale green, and gold for his beds. Antennaria

is the plant generally employed to get the delicate silvery white effect so often seen in the best carpet beds, while for very deep red effects the beet is occasionally employed with advantage. The deep blue and white varieties of lobelia are also valuable aids to carpet-bedding. No carpet bed would be complete unless it contained some of those curious flat rosette-like plants called *Echeveria secunda*. They are raised from seeds sown on fine soil in gentle heat, and merely require protection from frost in winter.

Where a centrepiece is desired for a carpet bed, and such a thing is often an improvement, it is best to employ the fishbone thistle (*Chamæpeuce cassabonæ*), a graceful plant, with shining dark-green leaves marked with white and brown.

The following are in general use as carpet bedding plants, but they require no special treatment: *Alyssum maritimum*, *Mentha pulegium*, *Iresine lindeni*, and *Sedum glaucum*.

Summer and Autumn Bedding Plants. Among gardeners the term "summer bedding plants" is understood to comprise those plants which, although invaluable for giving us a display of bloom, say, from May until September, are too delicate to withstand the rigours of our winters, and need the protection of a frame or greenhouse, or at lest a shed, if they are to be kept alive. Until comparatively a few years ago, summer bedding was confined to the laying down of strips of blue lobelia, scarlet geraniums, and yellow calceolarias, which occurred in garden after garden with never varying monotony: but things have now happily altered for the better, and a wider range of effect is possible. In the genial climate of the south and west of England some of the plants described hereafter as needing protection during the winter may remain in the open ground all the year round with impunity, but this favoured area is of such small extent that for practical purposes it is necessary to treat summer bedding plants as being only half hardy. The flowers enumerated hereunder are those most generally in use for the purpose, and may be supplemented, where space and opportunity affords, by any of those mentioned in other sections.

The Geranium, Fuchsia, and Begonia. The geranium, as most people know it, is not a geranium at all, but a pelargonium: it originally sprang from the wild geranium, but has been crossed with various species in order to obtain fresh varieties. It is the most popular of all summer and autumn bedding plants, and one of the easiest to cultivate well. It will grow in any ordinary garden soil, and is increased by taking cuttings, or slips, when the flowering season is practically over—say, in September. These slips should be cut off the parent plant at a very acute angle with a sharp knife, and should be put into little pots containing some fairly good soil, and with a pinch of sand at the bottom of the hole where the cutting is stuck in. As soon as there is any fear of frost they should be got in under glass, and they will quickly root and be ready for planting out the following May. Cuttings may also be struck in the spring, in slight heat, and will be ready for planting out at practically the same time, but they will not make such sturdy plants. Very little water should be given during the winter.

Fuchsias thrive in soil similar to that suitable for geraniums. They are, however, propagated in a somewhat different manner. It is customary to take old plants which have been stored in a cellar or somewhere else away from frost during the winter, and start them into growth in the heated greenhouse. When the young shoots appear, and are about two or three inches in length, they should be taken off and potted up as directed for geraniums. They should be thoroughly hardened off by exposure to light and air before being planted out. In some gardens, especially near towns, the buds of the fuchsia have a provoking habit of dropping off instead of opening into flower. The general cause of this is insufficient water, or, if the fuchsias happen to be growing in pots instead of in beds, it will probably be found that they are "pot bound"—that is to say, the pot is not large enough to contain the roots which have been formed. When this is discovered to be the case the plant should be re-potted at once.

The begonia of so much value for summer and autumn bedding is what is known as the tuberous-rooted begonia. It is best raised from seed or leaves sown in early spring in pans [18] or boxes in sandy soil and brought on in a temperature of not less than 60°. In three weeks or a month's time the plants will be ready to be put into pots, after which they should be gradually hardened off for planting out in June. Great care should be exercised in the sowing, as the seed is so very minute. In a rich, light soil begonias will continue to flower until cut down by frost. When this happens it is usual to lift them up, and store the tubers which will be found to have formed at the roots, in silver sand in a dry place. These tubers can be started into growth again in the spring. There are many sorts, in all shades of white, yellow, salmon, and red, and some double ones.

Dahlias, Calceolarias, and Other Bedding Plants. When the summer begins to wane there is probably no more important bedding plant in the garden than the dahlia, as it forms stout bushes three or four feet in height, giving a generous supply of bloom for cutting, right into the very late autumn. There are four principal kinds: the double dahlia, which is the old-fashioned almost spherical-shaped flower so often found in cottage gardens; the pom-pom, which is a smaller edition of the double dahlia; the cactus, distinguished by its almost claw-like petals; and the single dahlia. The dahlias are generally propagated from cuttings, which are obtained by starting a tuber into growth in a heated greenhouse in January or February, and taking off the cuttings as the young shoots appear. These are then treated in the manner described for seedling begonias. When the dahlias are thoroughly hardened off, and ready for planting out, a stick some four feet in height should be pushed into the ground at the side of the hole dug to receive each plant, and to this stick the young dahlia should be tied sufficiently tightly to prevent it being swayed about by the wind. After flowering, the bulbs should be lifted and stored in a box of soil in a frost-proof place during the winter.

The yellow calceolarias are a familiar sight in the summer bed. They are propagated by cuttings taken in the autumn in sandy soil, and placed in a cold frame, where they will root during the winter, and so be ready for planting out with the rest of the bedding stuff.

The canna is as effective in the summer garden for its foliage as for its flowers, most of the varieties having rich brown leaves. A group of cannas in the centre of a large bed is particularly effective, reaching, as the plant often does, to a height of six feet. They are propagated by spring cuttings, in the manner described for fuchsias, or by dividing the old roots, and potting them up. They need a sunny position, or they fail to develop. The best sorts are Antonin Crozy (crimson), Antoine Chantin (salmon colour), and Paul Bert (yellowish red).

The heliotrope is best known under its old-fashioned name of "cherry pie," and the little

flower is a great favourite because of its delicious perfume. It is propagated in the same way as the fuchsia, or forced from seed and hardened off. It is generally a failure in moist soil, and, when desired there, should be kept in the greenhouse.

Petunias and Tobacco Plants. The petunia is a hardy annual, raised from seed sown in heat in February, and planted out in May. Particular care must be taken in planting out as the roots of the plants are very brittle, and liable to damage if they are at all carelessly handled. Seedling plants often yield bloom with very curious markings, and if it be desired to perpetuate these it must be done by cuttings taken in August, and placed in pots or a frame in soil which is well mixed with rotten manure and kept moist. They must be wintered in a cold frame, and care taken that the frost does not get at them. Good bedding sorts are Countess of Ellesmere (crimson with paler throat), Delicata (white with purple stripes), and Doctor Hogg (purple with white throat).

No garden is complete without its tobacco plants, as the varieties of nicotiana are popularly called. They should be treated as half-hardy annuals, and raised from seed sown in heat in February, when they will be ready for planting out with the rest of the summer and autumn bedding stuff. The one most frequently met with is *Nicotiana affinis*, particularly sweet scented in the evening, and reaching a height of about two feet. A taller variety is called Sylvestris—three feet in height, the flowers of which do not shut when exposed to the full glare of the sun, as is the case with Affinis. A very interesting variety is called Sanderæ, having red flowers.

22. LAYERING CARNATIONS

The Hardy Ferns. In order to grow hardy ferns to the best advantage they must have a shady position in the garden. It is not, of course, impossible to grow ferns in the sun, but it is hopeless to expect them to do well there, as they soon get scorched up. Ferns dislike being moved; hence, to get the best results, the fernery should be established at some spot in the garden where it is likely to remain for a number of years. A sloping bank makes an ideal spot for a fernery, but, no matter where it may be, it is essential that the ground should be well drained. Ferns will not flourish when they have a lot of stagnant moisture about their roots, though, at the same time, the majority of them thrive admirably in the neighbourhood of a running brook or stream. The ideal soil for the fernery is a mixture of good loam and peat, the former predominating.

Ferns are usually propagated by taking the seeds, or spores, which are found upon the backs of the fronds, and spreading them carefully upon the surface of a lump of peat, keeping the peat thoroughly moist, when the majority of the seeds will successfully germinate. Those ferns which have running roots, however, may be divided in the usual manner. In order to ensure that fresh bright green appearance so much to be desired in ferns it is necessary that the foliage should have plenty of water. In small indoor ferneries this moisture is often supplied by the introduction of a small fountain. Out of doors the best substitute is frequent soaking with the hose, the rose of which has holes of the smallest size.

There are several varieties of spleenwort (asplenium) ranging from one to two feet high respectively. The most important is the black spleenwort (*Adiantum nigrum*) which, in addition to being grown among other ferns, may be planted with success at the foot of such shrubs as azaleas to act as a carpet. Its fronds are also useful when bouquets have to be made up, or to mingle with cut flowers for general decorative purposes.

Royal and other Popular Ferns. The Royal fern (*Osmunda regalis*) is rightly named, as it is the largest and most imposing of all our native ferns. It has been known to attain a height of eight feet, though its average altitude is not so much as this. It wants damp peaty soil, and may, in fact, be planted with its roots in water in a shady spot. There are several varieties, natives of North America, useful where large collections are being made, but otherwise not of great importance.

One of the most popular ferns is Hart's Tongue fern (*Scolopendrium vulgare*), deriving its name from the shape of the fronds. Like most other ferns like shade and moisture, but has the characteristic of thriving particularly well in a soil containing lime. It is attractive when grown in pots for the table.

The Lady fern (*Athyrium*) is another family of ferns much overladen with valueless varieties, but the type is worthy of cultivation under orthodox conditions in the fernery, or among evergreen herbaceous plants. It dies down during the winter, and, therefore, requires no water then.

A very useful hardy little fern is Polypody (*Polypodium*), the fronds of which are green all the year round, and which may be grown on walls or in rock work. It is one of the easiest of ferns to propagate, being easily increased by dividing the roots—an operation best carried out in the springtime. It prefers a liberal admixture of sand in the soil in which it is grown.

The Shield fern (*Aspidium* and *Polystichum*) is one eminently suited for culture in town gardens, as it will thrive in a comparatively poor soil provided it has plenty of water during the hot months. The Shield ferns are particularly useful for planting under trees, where there are often bare spots upon which grass refuses to grow. The well known Holly fern is a variety of this family, of which considerably over 100 members are found in catalogues.

There are several other families of ferns, individual members of which are worthy of a place in our gardens, where a speciality is being made of the fernery. The system of nomenclature by which they are distinguished is a very confusing one, and the young gardener who hopes to get on in the world can occupy his time far better in doing more useful things than, for instance, trying to identify *Athyrium filix-fœmina flore pleno superbum percristatum*, which is a rather insignificant variety of the Lady fern. In any case too many ferns in a garden are a mistake, and unless the place is of any considerable extent it is perhaps a mistake to lay down a fernery at all.

Continued

THE CONSTRUCTION OF DOCKS

Dock Walls and Foundations. Dock Gates. Caissons. Graving Docks and Floating Docks. Sea Walls. Lighthouses

By A. T. WALMISLEY

THE preliminary consideration for a dock is the choice of a site. Low-lying lands along tidal portions of rivers and estuaries are generally utilised, and thereby the amount of excavation is much reduced, and what is required to be dug out can be employed in making up the backing of the quays. Bends in the rivers furnish very suitable sites for docks, the surfaces being low. In sharp bends the dock is carried right across the bend, with an entrance at each end. The bends of the River Thames at London, also of the River Medway at Chatham, have thus served as sites for docks.

There are various types of docks, and their design depends upon the condition of the site, the nature of the traffic, and possible future extension. The length given to a dock depends upon the site, and the width is regulated by the size of the vessels using the dock. The depth depends upon the water-level at neap tides, depth of the approach, river, or channel, and the draught of the vessels that will frequent the dock. The deepening of a dock is a very expensive process, involving the consideration of the underpinning of all adjacent walls where their foundations are shallow. Hence the depth of a dock at the outset of its construction is of primary importance.

Dock Walls. Dock and quay walls form a very important feature in the construction of docks, as upon their design, the foundation, and the materials used, the total expenditure of a dock mainly depends. The object of dock and quay walls is not only to utilise the area of the dock, but also to enable vessels to lie alongside for loading and discharging, which they cannot do against a sloping bank unless it is piled out. Fender piles are introduced, and a coping that will bear the run of loose chains surmounting the quay wall. The foundations adopted for dock walls depend upon the nature of the soil to be built upon. In firm ground, the walls are generally built upon it direct, the excavations being increased in depth accordingly. If the ground is soft for some considerable depth below the intended level of foundation, other means have to be resorted to—namely, bearing piles, driven until they reach a hard stratum, the tops of the piles being connected by walings, and upon this staging the wall is built. If the ground is soft, a layer of concrete is put in between the piles and walings, and the wall is then built upon this continuous layer of concrete, which must be thick enough to distribute the pressure.

Pressure upon Dock Walls. Quay walls act as retaining walls, since they retain the earth at the back. The presence of the earth tends to overturn the wall by causing it to slide forward, or to turn on its outer edge. The pressure depends upon the nature of the soil and its condition, and is always increased by the presence of water at the back of the wall; also by the weight of cranes; and the effect of goods traffic on rails, if provided, must be duly considered.

The pressure varies with the depth, and may be provided for by increasing the width by means of steps from the top towards the bottom, the face of the wall being generally built on a batter. The width at the base is generally from one-third to half the height, according to circumstances. Counterforts are also built at certain intervals. A straight batter to a dock wall is preferable to a curved one, as it enables vessels to approach close to the wall. Its foundation is also easier to construct when a firm stratum is obtained. The ground is excavated vertically to a depth sufficient to secure the wall from being pushed forward, and the foundation, generally of concrete, is then put into position. The foundations are generally put in in short lengths, to reduce the cost of pumping and to avoid possible slips. The remaining concrete forming the wall is then carried up in layers, with proper precautions as regards the laying of one course over another.

Failures in dock walls are caused chiefly by slips of the ground at the back of the wall and by the pressure of the water behind at low water tending to push the wall forward. A concrete toe is generally built at the foot of a wall to add to the stability of the wall and to obviate the effect of scour. The coping of a dock wall is generally of granite, but special concrete is used in some of the new walls at Liverpool. Coping-stones are dowelled together, so that they may not be displaced by blows.

Foundations. While rock is the best material for foundations, it is sometimes treacherous, and beset with difficulties unless properly dealt with. In some cases the surface of the rock is irregular, but is easily dressed to the required level when the rock is not too hard to admit of this treatment; but when such a course cannot be adopted the rock may be roughly dressed and levelled to receive a course of face stones bedded in cement mortar. In the case of extreme unevenness of surface of the rock, mass concrete may be deposited from skips or bags, confined in position by boarding or bags of sand. Bags of concrete are sometimes used instead of mass concrete, but do not make such a satisfactory job.

It is often found expedient to bench the rock if it is inclined, and light charges of dynamite or other explosives are used to attain this result. Prior to building upon rock, all sand, gravel, or mud, together with all weed and other sea growth, must be removed to provide a clean surface for the adhesion of the superstructure. A small grab is suitable for such work, but if the surface of rock is too irregular, the work must be executed by divers.

Sand is an excellent foundation, being practically incompressible, but must on no account be allowed to escape from its natural position. In building breakwaters upon a sand foundation, rubble stone is deposited over the site and extended well seaward, forming a wide apron to protect the sand from scour. Sand may be found by boring to overlie some stable ground, when it can be removed by a sand pump and the firmer rock bed laid bare. Boxes filled with sand have been known to retain heavy weight resting on the sand without depression

until the sides of the boxes have received a shock, with the result that the sand has immediately sunk.

Mud foundations, if not of great thickness, should be removed to the more solid ground underneath. If depth of water permits, piles may be driven over the entire area to be occupied by the superstructure with proper cills and layers of planking. The mud should then be removed for a depth of 4 ft. or 5 ft. below the pile heads, and good concrete put in. Sheet piling along each side will increase the security against scour and undermining.

Gravel may be similarly treated, but is not so liable to sinkage as sand described above, while clay depends upon its character, whether hard and compact or soft and treacherous, like mud. Clay must be protected from scour.

In the case of foundations upon rubble, after a deposit of rubble a lime bed for the reception of blocks may be formed of small broken stone, which divers can pack and arrange to the required level. Sometimes the surface may be sealed by a layer of soft concrete in small bags.

Cylinder Foundations. Cylinder foundations are not economical if several cylinders have to be sunk together, hence it is better to make one cylinder sufficient for one girder of a bridge than to use two or four cylinders to support a platform suitable for a pier. They are usually adopted for foundations in deep water, required to be sunk to a considerable depth in the ground. Where rock has to be dealt with, cylinders can be used provided the rock is first levelled off by divers or other means to ensure a level bed being obtained for the cylinder. The cylindrical form is preferable to an oblong, square, or flat elliptical section in plan, as it best resists internal pressure and collapse, and is suitable for soils such as clay, which is likely to swell. Cylinders should not be sunk nearer together than 3 ft., and for considerable depths in sand not nearer than one-fourth to one-fifth of their diameter. One or two large cylinders used in preference to a number of smaller ones are liable to get out of the vertical in sinking. The thickness of metal generally used for cylinders ranges from 1 in. to 1¾ in. The cylinders should be cast in such length that vertical joint flanges are not required. The rings are usually cast in lengths of 9 ft. It is almost impossible to sink cylinders so that their tops are level, their subsidence under a load not being uniform or the strata perfectly horizontal. The top or making-up ring should not be cast until the test load has been removed from the cylinder. The cutting ring should have a chisel-pointed cutting edge, and its form should be suited to the material it has to penetrate. The cutting ring is best made of wrought iron because of its not being so liable to fracture from blows, and its more uniform strength. It should be well strutted and stayed to prevent deformation. The upper rings are best of cast iron, being cheaper, and they are more easily and quickly bolted together. If the cylinders have to be sunk to a considerable depth, the diameters should be sufficiently large to allow for any unavoidable deviation in sinking which may occur. The joints of cylinders may be caulked with iron-rust cement for half of the outer thickness of the rings, and the remaining space filled in with Portland cement. Cylinders are sometimes lined with tarred felt to allow for the expansion of the concrete in the hearting or filling, the freezing of water or unequal contraction, and expansion of iron and material used for filling in the cylinders.

Sinking Cylinders. A cylinder foundation should be weighted with a load equivalent to that which it will be called upon to sustain, and the equally distributed load on the hearting of the cylinder should remain for some days to ensure no future settlement.

Rocks are usually not loaded with more than 8 to 10 tons per sq. ft., according to the description of the rock; sandstone rock, if soft, 1½ to 1¾ tons per sq. ft.; soft clay, ¼ ton per sq. ft.; damp clay, 1½ to 2 tons per sq. ft.; loose sand, 2½ to 3 tons per sq. ft.; solid clay and firm sand, 4 tons per sq. ft.; blue clay, 5 to 8 tons per sq. ft.; soft chalk, 1 to 1½ tons per sq. ft.; hard chalk, 2½ to 4 tons per sq. ft.

The sinking of cylinders can also be executed by the Plenum, or compressed air method, though usually the cylinders are forced down by weight, the material in the interior being excavated by dredgers, grabs, or excavators, or the exterior may be excavated by divers, or the interior dredged till rock is reached, the bed being levelled by divers if necessary, and sufficient concrete deposited to keep back the water, and then the water pumped out of the cylinder. Cylinders can be sunk in loose soil, mud, silt, sand, and gravel, overlying impermeable stratum at a moderate depth, by the aid of pile staging erected around the site.

Cylinder Rings. A number of rings to reach, when sunk, a little above the water-level, being bolted together and caulked, are lowered into position by a travelling crane working on a stage. The loose soil being taken out by a grab dredger, fresh rings are added as the cylinder sinks until impermeable soil is reached. The water is then pumped out, and the excavation continued. Great care must be taken that the cylinder is perfectly vertical at the beginning of the sinking. The excavation should be carried out uniformly over the whole surface to ensure the cylinder sinking equally. Should two cylinders have to be sunk close to each other, or less than a diameter of a cylinder apart, they should be sunk alternately, not simultaneously, otherwise there is a tendency to draw towards one another. In lowering the water in a cylinder by pumping, blows frequently occur—that is, the soil will rush up from below, and possibly fill the cylinder.

Such blows also occur in sinking cylinders from the compressed air escaping under the cutting edge. They generally take place in loose, porous soils by changes in the water-level owing to great range of tide or wave action, but may be arrested by carefully lowering the air pressure so as not to endanger the lives of the men. In sinking cylinders, boulders varying in size are frequently encountered and often tilt the cylinder. They are often difficult to remove, requiring to be drawn into the cylinder, pushed outwards, split or drilled. As regards the kentledge required for sinking a cylinder, balks of timber are placed across the top of the cylinder and medium-sized stones packed upon them, or pig iron is usually employed. The weight must be adjusted so as to be distributed equally to ensure uniform sinking. Placing the kentledge on the top of the cylinder raises the centre of gravity, and the kentledge is often laid upon stages placed within the cylinder, thus reducing the tendency of the cylinder to tilt. The quantity of kentledge required depends upon the nature of the soil through which the cylinder has to be sunk, its size and depth in the ground. In calculating the kentledge required, when the compressed air system is employed the lifting power of the air pressure must be added. The hearting usually consists of Portland cement, concrete, brickwork or masonry.

In the compressed-air system of sinking cylinders the chief points to be considered are sufficient supply

of air for the expulsion of the water, and for the men in the working chamber, together with the provision of ready entrance and exit for the men, introduction of plant and materials, and discharge of material excavated.

Well Foundations. Upon the suitability of well foundations as an alternative to the use of cylinders, the following points have to be considered. The soil should be loose strata, not firmer than sand. The probability of debris and boulders and other obstructions, such as hard stratum, would render the employment of cylinders preferable, while in compact soil the sinking of a brick or concrete cylinder, on a curb, would be difficult, and an iron cylinder with a fine cutting edge would be preferable. The well system is economical in sand and silt, if the water is of moderate depth. Suitable plant and excavating apparatus must be used, if the depth is too great, by the employment of compressed air. Well foundations may consist of masonry, concrete, or brickwork, and the remarks on cylinder sinking are generally applicable to well sinking.

Borings. Borings should be taken to ascertain the nature of the soil to be excavated, and also the strata to be built upon. Ample borings should be taken upon the site, as the depth and thickness of the different strata vary considerably. Care should be taken in examining the materials taken from the boring tool and allowance made for the alteration in their consistency due to the action of boring. Trial pits are preferable, and afford more reliable information than borings, and should be used in preference to borings, when the question of water permits of their use. In a trial pit, the inclination or dip of a strata may be taken with the aid of a clinometer.

Cofferdams. A cofferdam is generally comprised of two rows of timber piles driven into the ground to a sufficient depth, the distance between the rows being 3 ft. to 5 ft., the intervening space being filled in with clay puddle. The clay should be carried down to as impermeable a stratum as possible. Horizontal walings are attached to the piles to prevent them yielding to the pressure of the clay puddle inside. Further support can be given by means of struts inside, and by a bank of approved earthwork or chalk against the inner fall. Cofferdams are used to keep back the water from the site of a proposed dock, to permit of the building of the walls. Temporary earthenwork dams, though cheaper in the first case, become costly in their removal owing to the large amount of material used, so that a cofferdam is deemed preferable [see also page 1402].

Pumping. The levels of the foundations of docks, walls, etc., are generally considerably lower than the ordinary water-level found in the ground, hence pumping is necessary when diving is not introduced to enable the excavation to be carried down to the required depth. Pumps should be sunk at the lowest point, and be in duplicate so as to meet all contingencies. As the lift frequently exceeds 30 ft., chain pumps and centrifugal pumps are employed. An experienced contractor can generally suggest to the engineer a reliable mode of procedure in such a case.

Dock Gates. A dock gate, when closed, is subjected to the direct water pressure on the gate itself, which increases with the depth and varies with the length, and produces a strain on the gate similar to that on a uniformly loaded girder. It also has to resist the pressure transmitted to the meeting-post by the other gate. This compressive strain acts in the direction of the length of the gate, and may be regarded as equal to half the water pressure on the gate multiplied by the tangent of half the angle at which the two gates are inclined when properly closed. The angle depends on the inclination of the faces of the sill, or the projection of the sill in proportion to the span, commonly called the *rise* of the gates. Gates are usually curved so as to form, when closed, a continuous circular arc, and acting as an arch sustaining horizontal normal pressures, the transverse strain disappears and the whole strain becomes converted into a compressive strain acting in the direction of the length of the gate, is the same on each horizontal section, and increases with the depth owing to the increased increment of water pressure. This strain is evidently equal to the pressure on a circuit of surface multiplied by the radius of curvature. The rise given to a gate affects considerably the compressive strain on the gates, the strain varying inversely as the rise. A small rise increases the strain on the gates, and the length of the gate is at the same time reduced. With a large rise, the reverse is the case.

Materials for Dock Gates. Dock gates are constructed of wood and iron, wooden gates being better able to resist shocks and possessing more elasticity. Wooden gates are composed of heelpost and meeting-post at each end, connected to a framework of horizontal ribs to which a sheeting of planks is fastened, forming the skin to the gate to retain the water. All joints are caulked to ensure the skin being watertight. Greenheart is the best wood for gates exposed to salt water.

Iron is better suited for large gates, but to resist corrosion it should be thoroughly painted at water-level and covered with black varnish below water-level. Iron gates are built with a double skin of plates connected to a framework of vertical and horizontal ribs made up of plates and angles and tees, with manholes to admit of access inside the gate. The exposed edges of all plates should be kept clean and free from mud deposit, as the mud aids corrosion. The heelpost, meeting-post and sill-piece are made of greenheart.

Forms of Dock Gates. There are various forms of dock gates—*straight* dock gates, meeting at an angle; *curved* gates, meeting at an angle, and, when closed, taking the form of a Gothic arch; and *segmental* gates, forming a circular arch when closed. The sill is generally made straight for any design; a straight proprietary sill-piece is fastened to the bottom of the curved gate. Sluices are made near to the bottom of the gates, and closed by sliding doors, raised or lowered by rods worked by a screw on the top of the gate. The heelpost is supported at the bottom on a steel pivot let into the heelpost stone, and turning upon it. At the top it is held by anchor bars built into the wall and also long tie-rods anchored in the back of the wall, thus allowing the gate to revolve. An additional support is given to the gates in the form of a roller near its outer end, the centre of the roller being fixed in the same vertical line as the intersection of the centre of gravity of the gate and the centre of the heelpost; in curved gates it falls outside the gate. The roller is made slightly conical for rolling along its curved path, and adjusted by means of a rod attached to the top of the gate to ensure its always bearing upon its path. Rollers are not necessary for small gates, and in iron gates are often dispensed with, a counterbalance weight of water ballast being placed in the gate near the heelpost to reduce the strain on the anchor straps. In very large and wide gates two roller paths

concentric with one another are provided to each gate. Gates may be opened and closed by chains attached to the gates and passing round drums turned by capstans or by hydraulic engines. Four separate chains are required, and they are attached more than halfway down the gate near the lower support of the roller to avoid straining the gate and to facilitate motion. Chain passages are constructed in the walls of the dock, with guide rollers for the chains. Hydraulic rams are also used, but when introduced are attached at a higher level, so that their actuating machinery may be above water-level.

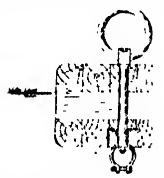
Single skin gates are not much used now. As gates are seldom opened except at or near high water, double-skin gates are more buoyant, and adapt themselves better to the usual requirements. In case of a fracture by a vessel running into a gate, there are two skins to break through instead of one, and the water in the dock is less liable to be lost in consequence. Double skin gates are in themselves heavier than single skin gates, and double-skin gates are liable to leakage and difficult to repair consequent upon the deposit of mud within them, besides their buoyancy under the influence of a difference of level between high and low water.

For greenheart gates, the difficulty is to obtain the material. At Liverpool they have the pick of all the best timber; but even there there is difficulty in obtaining enough for a large pair of gates.

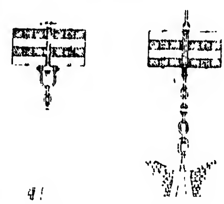
Caissons. There are two types of caissons—sliding and floating. The advantage of their adoption is to shorten the length of the entrance. They dispense with the hollow quoins. They facilitate maintenance and repairs, and when made to be capable of carrying a road or railway along their top they obviate the cost and inconvenience of a swing bridge across the entrance.

Sliding caissons are usually constructed rectangular in section, and are drawn backwards and forwards by hauling gear fixed at the inner end of the caisson chamber, the weight of the caisson on the sliding ways or rollers being adjusted by the amount of water admitted to the water chambers. The power applied may be steam, compressed air, electricity, or hydraulic power. A sliding caisson is found to effect a saving of time in adjustment and removal. Rolling caissons are of similar construction, and have rollers to the bottom of the caisson, or slide on rollers attached to the dock floor. A chamber is provided on one side of the walls of the dock to receive the caisson when not in use.

Floating caissons, termed "ship caissons," are built of plate-iron sides, with angles and tee stiffeners and diagonal braces. They are divided into several water-tight compartments and air chambers by means of the bulkheads. Flotation is provided by the air chamber, while others are ballasted. and so can be floated in and out of position. The width on the top depends on the nature of the road or footpath to be carried over. A recess is formed in the bottom of the dock to receive the keel of the caisson, and the projections on each side of the dock walls at the entrance for the caisson to press against. The caisson being required to close the dock entrance, is floated into its place against the side wall projections, and water is then admitted into the air chambers, causing the caisson to sink into the recess in the dock floor.



7. BUOY, ORDINARY PATTERN



8. MOVING BUOY

Graving Docks. An ordinary graving dock is a chamber of sufficient size and depth to receive the vessel that is required to be cleaned or repaired. For this purpose the vessel must be placed high and dry, and adequately supported. Graving docks are also called "dry docks." They communicate with a wet dock, or have access to deep water outside, and the entrance is closed by a pair of dock gates or by a caisson. The side walls are formed to the outline of a vessel, with steps or altars to receive the timber props supporting the vessel in an upright position. The keel of the ship to be examined or repaired rests upon keel blocks. Upon a vessel entering a graving dock at or near high water, the entrance is closed, and the water is allowed to run out by means of the sluices to the level of low water; the sluices are then closed, and the remaining water in the dock is pumped out. As the water lowers in the dock, the vessel is gradually propped up by timbers. The dimensions of graving docks vary according to the class of vessel to be provided for. Portsmouth graving dock has a length of 491½ ft., and is 110 ft. wide at the top, with a maximum depth of 42½ ft. Graving docks, being fixed structures, are lined with brickwork, concrete, or masonry; the facing to the walls being liable to rough usage, caused by the props used in supporting a vessel, are, where possible, protected by special recesses to receive such props.

Slipways. Slipways require a large space, but are less costly in construction and pumping than a graving dock. Vessels are liable to strains if any settlement in the foundations occurs. The vessel is deposited upon a cradle and hauled up the slipway by hydraulic or other power. The centre of the cradle sustains the weight, the bilge blocks merely serving to steady the vessel at the sides. A slipway provides better ventilation and light than a graving dock, but the cradle has to be specially adjusted to provide an even keel.

Floating Docks. The use of floating docks depends on the physical conditions of the site. In the United Kingdom there are comparatively few floating docks, because, owing to the rise and fall of the tide, graving docks are preferred when a site is free from springs. In non-tidal or only slightly tidal waters, such as those of the Baltic and the Mediterranean, floating docks are chiefly used.

The One-sided Depositing Dock. This has only one side wall, arranged to regulate the descent of the dock under water and to give stability fore and aft. Transverse stability is afforded by a floating outrigger attached to the dock by several pairs of hinged beams. So long as the outrigger keeps an even keel, the dock keeps a similar position. This type of dock is also capable of depositing vessels upon fixed stagings erected along the foreshore; the pontoon, instead of being continuous in construction, is composed of a number of short pontoons, with a space between them like a rake, which fits into another rake, formed by a stage. The shore stagings are thus constructed with the projections arranged so as to be capable of occupying the spaces left between the pontoons.

The One-sided "Off-shore" Dock. Instead of being controlled by means of a floating outrigger, this type of dock is provided with columns which are sunk in the foreshore, and the booms are

attached to them. In a combination of the "depositing" and "off-shore" types the pontoon is a continuous structure, and the booms are attached to the floating outrigger. The outrigger is used not only for stability, but to carry the boilers of the dock and small workshops.

It must not be forgotten that considerable depth of water is required for the installation of the floating dock. Dredging is often resorted to in obtaining a hole deep enough to receive the dock, but such a hole is apt to silt up and needs periodical re-dredging. A floating dock is further dependent upon the displacement of the vessel to be lifted not exceeding the dock's lifting capacity, whereas a vessel that can enter a graving dock can be docked irrespective of its weight. A sheltered position is also essential.

Groynes and Sea Walls. Groynes are used for the purpose of gathering the shingle and raising the beach of a fore-shore. They stay the littoral drifting action. Groynes themselves cannot be regarded as a protection, but are serviceable in the effect they produce on the beach. They do not creat fresh material, but rely on wasting cliffs, etc., to contribute fresh supplies, which they collect. Their formation has been discussed at length in the article beginning on page 5577, where also the construction of sea walls is considered.

Buoys. Buoys [7 and 8] are used for denoting positions in navigable channels. Their location is rendered serviceable by night as well as by day by charging them with compressed gas of a special kind which, as it issues forth, burns in a suitable apparatus, and cannot be extinguished by the waves. They are constructed of wrought iron and are of sufficient capacity for six weeks' illumination (burning night and day), and cost from £300 to £500 each, exclusive of moorings. The shore apparatus for making and compressing the gas costs £500 to £1,000, and storage tanks and buildings £500. Solid wooden buoys are liable to get waterlogged. Cask buoys are often used for mooring of vessels. Can buoys are used to locate the fairway of a channel. Bell buoys, or buoys with a hanging bell attached at the top, are useful at night or in foggy weather, the ringing of the bell being caused by the oscillation of the buoy; but light-giving buoys are the most satisfactory, the bell buoys having the disadvantage of limited range of sound in windy weather and absence of sound during calm weather.

Beacons. A wooden beacon may be formed with a wood pole well secured at its base in the ground or in a mound of stone, with a ball at the top. These beacons are used to indicate tides of a channel or estuary, and maintain their position during the rise and fall of the tide. In this way they are preferable to buoys, but buoys can be anchored where a beacon would not be available.

Iron beacons are usually constructed of iron tubes or of wrought-iron bars sunk into the ground or rock, rigidly braced together at the top of the beacon, and surmounted with a painted ball having distinguishing marks thereon in bold colours.

9. CAPSTAN

Capstans [9] are indispensable upon every commercial quay. They are sometimes worked by hand levers, sometimes by hydraulic power, and sometimes by electricity, which is now preferred to steam power for use upon a quay.

Lighthouses. Lighthouses serve to mark the sites of projecting headlands, entrances of harbours, and outlying rocks, also to indicate to a mariner the position of his course. Lighthouses are generally built conical in form, and constructed of stone or iron, with a lantern at the top. Stone is preferable to iron, as the former is not subject to corrosion. Lighthouses built on an isolated rock in the sea have the following serious difficulties to combat. The foundation of a lighthouse being below high-water level, or very little above low-water level, can be put in only during calm weather by the aid of divers, or executed as tide work. There is no shelter for workmen, and materials can be landed on the rock only as required. The approach to the rock is uncertain and at times dangerous. The distance of the depôt from the site is often considerable. The preparation of the foundations presents the greatest difficulties. Unsound rock must be removed and level benchings formed to receive the foundation courses, which are bolted or otherwise secured to the rock. The hardness of a rock upon which a lighthouse stands is of paramount importance in securing sufficient stability to the structure to be erected upon it. In stone towers the courses are dovetailed together both horizontally and vertically. The rate of progress depends upon the level of the rock and the exposure of the site, and is necessarily very slow at the beginning of the work. In lighthouses constructed sufficiently high to be out of the reach of the waves, store-rooms and dwellings for the lighthouse keepers are provided. Constant care and supervision is needed to maintain the efficiency of a lighthouse and its lantern. Oil, gas, and the electric ligh are used as illuminants, but of these three the first-named is preferred. Electric light possesses great intensity, but is reckoned to be inferior to the other lights in foggy weather. The distinction in character of the respective lights is made by a definite number of flashes in quick succession, following a certain period of obscuration, which enables the mariners to recognise any particular light.

In foggy weather signals are made by ringing a bell, or blowing a horn or trumpet and steam syrens. A similar arrangement of combinations of sounds can be made as above, worked from a lighthouse.

Screw Pile Lighthouses. This form of construction is adopted on sandbanks where the foundation is unsuitable for a more solid base. Such construction presents little obstruction to the waves, but requires protection from drifting ice.

Lightships are moored in different positions to serve as a warning to vessels of dangerous shoals, where lighthouses would either be impossible to build or too costly for the required purpose.

HARBOURS AND DOCKS *concluded; followed by* CIVIL ENGINEERING ABROAD

continued from page 6374

COMPOUND ANGLES

Ratios of 15° and 75°. Formulæ for Sum and Difference of Two Sines or Cosines. Multiple Angles. Logarithms

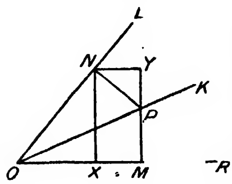
By HERBERT J. ALLPORT, M.A.

22. *Continued.* To prove that

$\sin (A - B) = \sin A . \cos B - \cos A . \sin B$

and

$\cos (A - B) = \cos A . \cos B + \sin A . \sin B.$



Let ROL be the angle A, and LOK the angle B. Then ROK is the angle (A − B). Making the same construction as before, we have ∠s PMO, PNO right ∠s. ∴ a ⊙ on OP as diameter passes through M and N. Hence ∠YPN is the supplement of ∠NPM, and ∴ is equal to ∠MON (*Prop.* 41), *i.e.*, to ∠A. Then

$$\sin (A - B) = \frac{MP}{OP} = \frac{XN - PY}{OP} = \frac{XN}{OP} - \frac{PY}{OP}$$

$$= \frac{XN}{ON} \cdot \frac{ON}{OP} - \frac{PY}{PN} \cdot \frac{PN}{OP}$$

$$= \sin ROL . \cos LOK - \cos YPN . \sin LOK$$

$$= \sin A . \cos B - \cos A . \sin B.$$

Again,

$$\cos (A - B) = \frac{OM}{OP} = \frac{OX + NY}{OP} = \frac{OX}{OP} + \frac{NY}{OP}$$

$$= \frac{OX}{ON} \cdot \frac{ON}{OP} + \frac{NY}{PN} \cdot \frac{PN}{OP}$$

$$= \cos ROL . \cos LOK + \sin YPN . \sin LOK$$

$$= \cos A . \cos B + \sin A . \sin B.$$

In the above proofs we have only considered the cases in which the ∠s A, B and (A + B) are each less than a right angle. It is left as an exercise to the student to draw the figures and modify the proofs for other values of the angles.

23. Ratios of 15° and 75°. The results of the last article enable us to find the ratios of 15° and 75°.

Example. Find the value of tan 75°.

$$\tan 75^\circ = \tan (45^\circ + 30^\circ) = \frac{\sin (45^\circ + 30^\circ)}{\cos (45^\circ + 30^\circ)}$$

$$= \frac{\sin 45^\circ \cos 30^\circ + \cos 45^\circ . \sin 30^\circ}{\cos 45^\circ \cos 30^\circ - \sin 45^\circ \sin 30^\circ}$$

$$= \frac{\cos 30^\circ + \sin 30^\circ}{\cos 30^\circ - \sin 30^\circ}$$

[Cancelling numerator and denominator by $\frac{1}{\sqrt{2}}$, which is the value of both sin 45° and cos 45°]

$$= \frac{\frac{\sqrt{3}}{2} + \frac{1}{2}}{\frac{\sqrt{3}}{2} - \frac{1}{2}} = \frac{\sqrt{3}+1}{\sqrt{3}-1} = \frac{(\sqrt{3}+1)^2}{3-1} = \frac{4+2\sqrt{3}}{2}$$

$$= 2 + \sqrt{3}.$$

The other ratios of 75° can be found in a similar way. In the case of 15°, we use the fact that 15° = 45° − 30°.

24. Formulæ for tan (A ± B). We have

$$\tan (A+B) = \frac{\sin (A+B)}{\cos (A+B)} = \frac{\sin A \cos B + \cos A \sin B}{\cos A \cos B - \sin A \sin B}$$

$$= \frac{\dfrac{\sin A . \cos B}{\cos A . \cos B} + \dfrac{\cos A . \sin B}{\cos A . \cos B}}{\dfrac{\cos A . \cos B}{\cos A . \cos B} - \dfrac{\sin A . \sin B}{\cos A . \cos B}}$$

$$= \frac{\tan A + \tan B}{1 - \tan A . \tan B}.$$

Similarly, we get

$$\tan (A - B) = \frac{\tan A - \tan B}{1 + \tan A . \tan B}.$$

By the same method the student can prove that

$$\cot (A + B) = \frac{\cot A . \cot B - 1}{\cot A + \cot B},$$

and

$$\cot (A - B) = \frac{\cot A . \cot B + 1}{\cot B - \cot A}.$$

25. The "S, T" Formulæ. We have already proved that

$$\sin (A + B) = \sin A . \cos B + \cos A . \sin B,$$
$$\sin (A - B) = \sin A . \cos B - \cos A . \sin B,$$
$$\cos (A + B) = \cos A . \cos B - \sin A . \sin B,$$
$$\cos (A - B) = \cos A . \cos B + \sin A . \sin B.$$

By adding and subtracting the first pair of results we get

$$\left.\begin{aligned} \sin (A+B) + \sin (A-B) &= 2 \sin A . \cos B \\ \sin (A+B) - \sin (A-B) &= 2 \cos A . \sin B \end{aligned}\right\} \quad . \quad . \quad (1)$$

Similarly, from the second pair we get

$$\left.\begin{aligned} \cos (A+B) + \cos (A-B) &= 2 \cos A . \cos B \\ \cos (A-B) - \cos (A+B) &= 2 \sin A . \sin B \end{aligned}\right\} \quad . \quad . \quad (2)$$

Let A + B = S, and A − B = T. By solving these equations we find $A = \frac{S+T}{2}$ and $B = \frac{S-T}{2}$.

Substitute these values of A and B in (1) and (2). Then

$$\sin S + \sin T = 2 \sin \frac{S+T}{2} . \cos \frac{S-T}{2},$$

$$\sin S - \sin T = 2 \cos \frac{S+T}{2} . \sin \frac{S-T}{2},$$

$$\cos S + \cos T = 2 \cos \frac{S+T}{2} . \cos \frac{S-T}{2},$$

$$\cos T - \cos S = 2 \sin \frac{S+T}{2} . \sin \frac{S-T}{2}.$$

These results should be remembered *in words*, thus

(i.) *The sum of the sines of two angles equals twice the sine of half their sum, times the cosine of half their difference.*

(ii.) *The difference of the sines of two angles equals twice the cosine of half their sum, times the sine of half their difference.*

(iii.) *The sum of the cosines of two angles equals twice the cosine of half their sum, times the cosine of half their difference.*

(iv.) *The difference of the cosines of two angles* [the cosine of the *less*, minus the cosine of the *greater*] *equals twice the sine of half their sum, times the sine of half their difference.*

The student must also be able to make a ready use of the results (1) and (2); *i.e.*, he must remember that the product of a sine and cosine can be expressed as the sum of two sines, and so on.

EXAMPLE.

3A A

$$= \frac{1}{2}\left\{\cos\left(\frac{3A}{2}+\frac{A}{2}\right)+\cos\left(\frac{3A}{2}-\frac{A}{2}\right)\right\}$$

$$= \frac{1}{2}\{\cos 2A + \cos A\}.$$

26. Trigonometrical Ratios of Multiple Angles.

By putting B = A in the formula

$$\sin(A+B) = \sin A \,.\, \cos B + \cos A \,.\, \sin B,$$

we get

$$\sin(A+A) = \sin A \,.\, \cos A + \cos A \,.\, \sin A$$

i.e., $\sin 2A = 2 \sin A \,.\, \cos A \quad . \quad . \quad . \quad . \quad (1)$

Again, from

$$\cos(A+B) = \cos A \,.\, \cos B - \sin A \,.\, \sin B,$$

we get

$$\cos(A+A) = \cos A \,.\, \cos A - \sin A \,.\, \sin A;$$

i.e., $\cos 2A = \cos^2 A - \sin^2 A. \quad . \quad . \quad . \quad .$

Since $1 = \cos^2 A + \sin^2 A$,

it follows that

$$1 + \cos 2A = 2\cos^2 A$$

and $1 - \cos 2A = 2 \sin^2 A$,

or
$$\left.\begin{aligned}\cos 2A &= 2\cos^2 A - 1\\ \cos 2A &= 1 - 2\sin^2 A\end{aligned}\right\}. \qquad (3)$$

Also, from

$$\tan(A+B) = \frac{\tan A + \tan B}{1 - \tan A \,.\, \tan B},$$

we get

$$\tan(A+A) = \frac{\tan A + \tan A}{1 - \tan A \,.\, \tan A};$$

$$\tan 2A = \frac{2\tan A}{1-\tan^2 A}. \quad . \quad . \qquad (4)$$

These four formulæ are important, and must be remembered. They are, of course, true for *all* values of A, so that it is just as useful to know the results obtained by putting A instead of 2A. Thus we have $\sin A = 2 \sin \frac{A}{2} \,.\, \cos \frac{A}{2}$, and so on.

27. Sin 3A in terms of sin A.

Sin 3A

$= \sin(2A + A)$

$= \sin 2A \,.\, \cos A + \cos 2A \,.\, \sin A$

$= (2 \sin A \,.\, \cos A) \,.\, \cos A + (1 - 2\sin^2 A) \,.\, \sin A$

$= 2 \sin A \,.\, \cos^2 A + \sin A - 2\sin^3 A$

$= 2 \sin A \,.\, (1 - \sin^2 A) + \sin A - 2 \sin^3 A$

$= 2 \sin A - 2 \sin^3 A + \sin A - 2 \sin^3 A$

$= 3 \sin A - 4 \sin^3 A.$

In a similar way we obtain

$$\cos 3A = 4\cos^3 A - 3 \cos A.$$

LOGARITHMS

28. By algebra we know that

(i.) The index of the *product* of two powers of the same quantity is obtained by *adding* the indices of the powers.

(ii.) The index of a *quotient* is obtained by *subtracting* the indices of the powers.

(iii.) The index of a *power* or a *root* is obtained by *multiplying* or *dividing* the indices.

These facts are made use of to shorten arithmetical calculations. A power of the number 10 can be found which is practically equal to any given number. For example, 2 is approximately $10^{\cdot 30103}$. The number 10 thus used is called the *base*; the index ·30103 is called the *logarithm* of 2 to the base 10. Hence,

DEFINITION. The *logarithm* of a number to a given base is the *index* of the power of the base which is equal to the given number.

Logarithms to the base 10 are, in general, incommensurable numbers. They have been calculated to seven significant figures, for all numbers from 1 to 100,000.

$\text{Log}_{10} 2 = \cdot 30103$, and $10^{\cdot 30103} = 2$, are different ways of stating the same fact.

29. From the index laws of Algebra we have

(i.) The logarithm of the *product* of two numbers is equal to the *sum* of the logarithms of the numbers.

(ii.) The logarithm of the *quotient* of two numbers is the logarithm of the dividend *minus* the logarithm of the divisor.

(iii.) The logarithm of a number raised to the *power p* is *p times* the logarithm of the number.

30. Since $10^0 = 1$, *the logarithm of* 1 *is* 0. Also, since $10 = 10^1$ and $100 = 10^2$, the logarithm of a number between 1 and 10 lies between 0 and 1, and that of a number between 10 and 100 lies between 1 and 2, and so on. Thus, *the logarithm of a number greater than* 1 *is positive.*

Again, $\quad \cdot 1 = \frac{1}{10} = 10^{-}$

$\qquad \cdot 01 = \frac{1}{100} = 10^{-}$

and so on, so that *the logarithm of a positive number less than* 1 *is negative.*

It is clear that the logarithm of a number between 1 and 10 is a positive decimal fraction: the logarithm of a number between 10 and 100 is equal to 1 + a decimal fraction, and so on.

Also, the logarithm of a number between 1 and ·1, *i.e.*, between 10^0 and 10^{-1}, lies between 0 and −1, and is therefore a negative decimal fraction. This *is equivalent to* −1 + *a positive decimal fraction.* Similarly, we see that the logarithm of a number between ·1 and ·01 can be written in the form −2 + a positive decimal.

Continued

DYEING MIXTURES

How Wool, Silk and Cotton are Dyed Together. Wonderful Colour Effects by Simple Methods

Continued from page 6372

By HERBERT ROBSON

WHEN the dyer has to deal with a mixture of animal and vegetable fibres in a fabric it is obvious that he has a more difficult problem to face than when he has simply to dye cloth woven solely of wool, cotton, or silk. In the days when the natural colours reigned alone it was necessary, generally speaking, even when a mixed fabric, say, of wool and cotton, was to be dyed a self-colour, to dye the weft and the warp separately before weaving. The general employment of the artificial dyestuffs, and especially the advent of the direct cotton colours, has changed all this. The dyer can dye a mixed fabric a single colour in one or more baths, or he can dye one fibre alone in the fabric, leaving the other white, or even, treating the cloth in a single bath, he can make the different fibres take up different colours. In short, he can ring the changes in a variety of ways, producing a vast variety of effects, the most important of which will be touched upon. This facility has naturally had a strong influence upon the manufacture of mixed fabrics; they are now woven in infinite variety and in ever-increasing quantities.

Mixed Effects. It is evident also that by taking advantage of the varied properties of the different dyestuffs, and of the action of certain chemicals upon the textile fibres, the dyer can produce mixed effects upon a fabric composed of whole wool, cotton, or silk. What lies in his power in this way would, in itself, furnish matter for a long treatise, but a few examples must suffice. It is obvious that if, say, the warp is mordanted before weaving and the weft is left unmordanted, then, on dyeing with a mordant colour, the warp alone will take up colour. If a suitable direct colour be added to the bath the fibres will be dyed in different shades. If, in the case of wool, part of the cloth is chlorinated, that part will take a darker shade than the rest, and the same effect is obtained on cotton by taking advantage of the effect of caustic soda upon the fibre. For instance, if the fabric is "slop-padded" —that is, treated on one side only with lye—that side will take up more colour out of the bath than the other. The intelligent student of this course will readily gather the infinite possibilities of variety in the light of these examples.

Again, in dyeing with yarn or cloth, merely mechanical contrivances can be brought into use to the same end. Portions of the yarn can be protected mechanically against the action of the dye-bath; to take a simple example, the hank or warp can be tied in tight knots at determined intervals. Cloth may be dyed in a tilted bath or passed unevenly through the dye liquor, or may be raised slowly out of a dye-bath, the composition of which is gradually changed.

Chemical resists and discharges are also employed to obtain a variety of effects, but these are used mainly by the textile printer.

Preparation for Dyeing. Union goods must be well scoured before dyeing and thoroughly wetted out. For dark shades they are sometimes entered dry into the dye-bath. In the case of thin cloths especially, they must be crabbed [see page 6198] and steamed to prevent "cockling"—that is to say, a shrivelled-up appearance of the cloth caused by the woollen shrinking in the dye-bath. Crabbing machines are sometimes provided with a hollow, perforated roller through which steam can be admitted, but the decatising machine, used also in finishing, is often employed. After thorough crabbing and steaming, the cloth is "set" and it is scoured in the usual manner. The simplest way seems to give the best results, and that is to add the scouring agent to the water in the crabbing machine, and to follow this by steaming the cloth.

Dyeing Mixed Goods. Broadly speaking, the dyeing of wool and cotton mixture cloths is simple. The goods may be treated in a bath of an acid colour and this goes on the wool only. If the cotton is slightly tinted, all that is necessary is to rinse well before dyeing the cotton. A simpler way still is to dye in a single bath with a direct cotton colour alone, or combined with a wool colour. In practice, however, trade requirements necessitate the use of a variety of methods that are not quite so simple. As regards their behaviour to wool and cotton, the dyestuffs may be divided into five groups, and these will suggest the variety of effects that may be obtained on union cloth.

1. Colours which dye wool and cotton equally, or nearly so.
2. Colours which dye the two fibres different hues.
3. Colours which dye wool a deeper shade than cotton.
4. Colours which dye cotton a deeper shade than wool.
5. Colours which dye wool alone.

The direct cotton colours can be categoried in the first four groups, and there are a number of wool colours which leave the cotton threads perfectly white when dyed in an acid bath. Some of the colours in group 4 leave the wool almost untouched.

The customary methods of dyeing may be grouped as follows.

One-bath Process. The goods are dyed with direct cotton alone or in combination with wool colours. This method is so simple that it has largely superseded other methods of dyeing. Colours may be chosen which dye the two fibres a solid shade, the wool deeper than the cotton, the cotton deeper than the wool, or dye the two fibres different hues. It is impossible to find space to enumerate all the direct colours suitable for these effects, and a few examples will be given from the diamine and dianil ranges.

(*a*) Colours dyeing wool and cotton alike:

Thioflavine S, Oxydiamine Yellow GG, Diamine Orange F, Diamine Rose GD and BD, Oxydiamine Red S, Diamine Red in several brands, Diamine Fast Red F, Diamine Brilliant Blue G, Diamine Green G, Union Black and Oxydiamine Black in a variety of brands, Dianil Yellow 3G, R and RR, Aurophenine O, Dianil Orange N, Dianil Red R, 4B 10B, Dianil Claret Red G, Delta Purpurine 5B, Dianil Blue BX, Dianil Indigo O, Dianil Black

N, E, Dianil Brown 3GO, 3R, and Dianil Copper Brown O.

(*b*) Colours which dye the two fibres different hues:

Diamine Brown VS, Diamine Nitrazol Brown B, Diamine Blue BX, Diamine Blue 3R, Dianil Brown 5G, Dianil Japonine G, Dianil Blue E, ET, and Dianil Black in several brands.

(*c*) Colours which dye wool a deeper shade than cotton:

Diamine Gold, Diamine Scarlet B, 3B, Diamine Bordeaux S, Diaminogene Extra, Dianil Yellow G, Cresotine Yellow G, Toluylene Orange R, Dianil Scarlet G and 2R, Brilliant Dianil Red, Dianil Black T, and Dianil Green G.

(*d*) Colours which dye cotton a deeper shade than wool:

Diamine Fast Yellow A, Diamine Orange G, D, Diamine Nitrazol Brown G, Diamine Catechine F, Diamine Sky Blue, Diamine Blue 2B, 3B, BG, Diamine New Blue R, Diamine Black BH, Diamine Dark Blue B, Diamine Bordeaux B, Diamine Violet N, B, Dianil Orange G, Dianil Brown in several brands, Dianil Fast Brown B, Dianil Blue in several brands, Dianil dark Blue R, 3B, Dianil Black in several brands and Dianil New Black.

If a wool colour is used for shading it must be capable of going on to the wool in a neutral salt bath.

The dye-bath is simply prepared with the required amount of dyestuff, usually from ½ per cent. for light shades to 2 per cent. for full shades, and from 30 per cent. to 50 per cent. of Glauber's salt. The material is entered at about 120° F., and the temperature is gradually raised to about 200° F. if a self-colour is required. As a rule, the wool will take more colour than the cotton if the temperature is raised to the boil. The dyer, therefore, must watch his goods and raise or lower the heat according to requirements.

It is always better to work for a lighter shade than the pattern, as it is always easier to add colour than to take it away. When the cotton is dyed to pattern, the colour to shade the wool is added if this is requisite. The addition of a little borax to the bath will cause the wool to take up less colour.

Ordinary Two-bath Processes. In this method the wool is dyed in the ordinary way with acid colour, and then the cotton with a direct cotton colour. The cotton, if required, may be topped with a basic colour. This process is best for producing "shot" or "changeant" effects—that is to say, the eye catches different colours on the fabric according to the direction the light strikes it. Some examples may be given.

Wool crimson, cotton green. Dye the wool with 3½ per cent. Naphthol Red C, 10 per cent. Glauber's salt, and 2 per cent. sulphuric acid; the cotton with 2¼ per cent. Diamine Sky Blue FF, 1¼ per cent. Thioflavine S, and 10 per cent. Glauber's salt.

Wool blue, cotton brown. Dye in a bath at 150° F., with 3 per cent. Diamine Orange G, 0·81 per cent. Naphthol Blue G, 0·91 per cent. Formyl Violet S4B, and 20 per cent. Glauber's salt.

Wool violet, cotton yellow. Dye the wool with 1½ per cent. Acid Violet 6B, 10 per cent. Glauber's salt, and 1 per cent. sulphuric acid; then dye the cotton with 3 per cent. Mikado Golden Yellow 8G, and 10 per cent. salt.

Wool green, cotton red. Dye the wool with 3 per cent. Guinea Green B, 0·25 per cent. Curcumine extra, 10 per cent. Glauber's salt, and 2 per cent. sulphuric acid. The cotton is dyed with 1½ per cent. Mikado Orange 4RO, 0·75 per cent. Erika 2GN, and 20 per cent. Glauber's salt.

Wool claret, cotton black. Dye the cotton first with 5 per cent. Diamine Black BH, diazotising and developing with phenylene-diamine in the usual way; then dye the wool in a fresh bath with 1 per cent. Brilliant Cochineal 2R, 1 per cent. Brilliant Cochineal 4R, and 10 per cent. bisulphate of soda working at the boil.

Wool olive green, cotton dull lilac. Dye the wool with 2½ per cent. Naphthol Green B, 0·5 per cent. Orange GG, and 10 per cent. bisulphate of soda working at the boil. The cotton is dyed in a bath which contains 1 per cent. Diamine Violet N, 0·25 per cent. Diamine Sky Blue, 20 per cent. Glauber's salt, and 3 per cent. soda working at a low heat.

Cross Dyeing. In the method known as cross dyeing the cotton warp is dyed before weaving, and the woollen or worsted weft is dyed in the piece. For instance, the cotton warp is dyed with Cross Dye Black 4B, the piece is woven up with the woollen weft thrown over the face, crabbed, steamed, and singed, and the woollen is then dyed with Acid Violet F or Disulphine Blue in a bath of Glauber's salt and sulphuric acid. Cross Dye Black and Cross Dye Drab are sulphur colours very suitable for this class of work, as they are very fast to acids and boiling water. The Acid Violet F and Disulphine Blue are used in extremely small proportions, say, 1½ oz. to 100 lb. weight of the goods, and the result is a bright-faced material which could be obtained in no other way. Cross-dyed goods have a softer handle than those dyed wholly in the piece.

Mordant Colours. The wool may be dyed with an acid colour, the cotton mordanted and dyed with a basic, or the cotton may be mordanted, and the piece may be dyed with a basic colour.

Cotton or ramie effect threads. A very popular style of dress material is made with a white cotton or ramie "effect" thread running through the goods, and showing on the face of the material in lines, stripes, dots or figures. Bleached or bleached and mercerised cotton must be used, as these goods are always dyed in the piece; the wool colours which will not even tint the cotton are alone admissible. As a rule, the acid and the chrome developing dyes are most suitable. A few examples will suffice.

Mode Shade with White Cotton Effect. Mordant for 1½ hours at the boil with 4 per cent. bichromate of potash, and 3½ per cent. tartaric acid. Rinse and dye in a fresh bath with 1½ per cent. Anthracene Chrome Blue B, ½ per cent. Brilliant Milling Blue B, 2 per cent. acetic acid. Enter at 120° F., raise to the boil in half an hour, and boil for one hour. Then add 3 per cent. acetic acid, and boil for another hour.

Black with white cotton effect. Prepare the dye-bath with 6 per cent. Carbon Black BD. 20 per cent. Glauber's salt, 3 per cent. acetic acid Enter at about 130° F., raise to the boil, boil for half an hour, then add 2 per cent. sulphuric acid, and boil until the bath is exhausted.

Black with white cotton effect. Prepare the dye bath with 6 per cent. Cashmere Acid Black MC or MCS, 20 per cent. Glauber's salt, 5 per cent sulphuric acid. Run the cloth in lukewarm, raise to the boil in half an hour, and dye at the boil for another half hour.

Dyeing shoddy. Union goods are sometimes woven from "shoddy"—that is to say, soft woollen rags worked up for re-manufacture. This generally contains "burls"—that is, cotton twisted into hard lumps in the shredding process. These

cloths are usually dyed in dark colours—for instance, a logwood black on a tannin and iron mordant. Sometimes, however, the colours are stripped with sulphuric acid or other agents, and the goods are dyed in the same manner as other unions. For lighter shades, the burls are sometimes picked out with burling irons.

Half-silk. Hummel in his manual, published in 1895, dismissed wool and silk, and cotton and silk (half silk) mixtures as of little interest, but lately they have come more and more into vogue, and are now of high importance. Half-silk goods, broadly speaking, are treated like unions, but with greater precautions as silk is more difficult to handle than wool.

Preparations for Dyeing. The goods are first singed, which must be done on the gassing machine, and as silk is more inflammable even than cotton, great care is needed. The goods are then scoured and rinsed in very soft water. A five-hole washing machine is suitable for this operation. The first scouring bath is made with good olive oil soap or white curd soap. For 100 lb. of half silk, about 40 lb. of soap is used, but for a second batch of 100 lb. of goods the addition of about 20 lb. of soap is sufficient. The bath should not be used for more than three batches, as an old bath will give the goods an unpleasant odour. The second hole is filled with soap solution made with 10 lb. of soap, and little addition is needed for subsequent batches. The next hole is a weak bath of soda to remove most of the soap. The fourth is water slightly soured with sulphuric acid, and the fifth is water alone in which a thorough rinsing is given to remove the acid. Only heavy goods require crabbing and steaming. If it is required to bleach the material this is done with sodium or oxygen peroxide.

Dyeing Half-silk. The colouring matters may be grouped in the same way as those for wool and cotton, with the exception that the last group is eliminated. In fact, the treatment of the two descriptions of mixture cloths only differ in so far as the physical properties of the fibre interwoven with the cotton are different. In dyeing half-silk, very little Glauber's salt must be used, and none at all for light shades, as the salt injures the lustre of the silk. The half-silk bath must be more alkaline than is requred for half-wool, and this secured by adding soap and carbonate or phosphate of soda. Soap is of great assistance in preserving the lustre of the silk.

In the one-bath process the half-silk is entered into the lukewarm dye-bath, which is then gradually brought to rather under the boil, at which temperature it is kept for about an hour. For light shades the bath contains soap, soda, or soap and phosphate of soda. For dark shades a little common salt is also added.

The cotton is allowed to dye in the cooling bath, and if the silk is to be darker the bath must be less alkaline. If, as happens with many dyes, the silk does not get sufficiently dyed, it must be topped with acid or basic dyes in a fresh bath with from 3 to 6 per cent. of acetic acid, cold for basic dyes, lukewarm for acid dyes. For getting two-colour effects (*changeants*), both wool and silk can be dyed together in some cases. For example, either Alkali Blue or Direct Yellow is dyed in one bath, followed by a rinsing and souring. The more usual practice, however, is to use dyes which leave the silk white, and then to dye the silk in a fresh bath with an acid dye of a colour contrasting with the cotton. Another method is first to dye the silk with dyes which leave the cotton white, and then to dye the cotton with a basic dye on a tannin antimony mordant. To load the silk the fabric is often put through a stannic chloride bath of 22° Tw. between mordanting and dyeing.

The tannin method is now used only in cases when greater purity and warmth of shade is demanded than can be got with a substantive dye. The general method of dyeing the silk as well as mordanting and after-dyeing the cotton is the same as for unmixed fabrics, except that, as in dyeing half-wool in more than one bath, it must be remembered that the after dyeing of the cotton always injures the shade more or less. The following are two illustrative recipes.

Magenta on Half-silk. Make a bath with 2 per cent. Fuchsine S. Enter lukewarm, and gradually heat up to 190° F., adding acetic acid to exhaust the bath. Finally boil the bath up, lift, rinse, mordant the cotton in a cold tannin bath with about 8 per cent. of tannin, and soured with a little hydrochloric acid, give a slight rinse, pass through a cold tartar emetic bath, rinse thoroughly, and finally dye in a cold acetic bath with 0·75 per cent. of Diamond Fuchsine I in needles. Finally rinse and centrifuge.

Shot Effect (Green and Red) on Half-silk. Dye the silk as above with Quinoline Yellow and Light Green SF yellowish. Mordant as above, and dye the cotton in a cold acetic acid bath with Safranine XX, and Auramine II, rinse and wring.

If the cotton dye goes too much on to the silk the mordanting was not done cold enough, or the goods were insufficiently rinsed after mordanting, or were not dyed cold enough, or there was not enough acid in the dye-bath. If the tannin bath is too weak the cotton will come out too light. There must be not only the proper total amount of tannin, but the solution must not be too weak—that is, the bath must not be too long. If a bronzy appearance is seen on the silk the water used has not been properly softened, or the soap was not rinsed out properly before dyeing, or too much dye was used.

Wool and Silk. A very great variety of fabrics composed of a mixture of wool and silk are on the market. The warp and weft are woven in a large variety of ways, and the difference of affinity and receptivity for dyes is taken advantage of by the dyer to produce many charming effects which have caused wool-silk fabrics to be always in request. A very ordinary form is a smooth fabric with silk warp and wool weft, but the warp or weft is sometimes thrown out on the face of the fabric in pattern.

Poplin, a dress fabric for which Ireland is famous, *Gloria*, largely used for umbrella and sunshade cloth, and *Henrietta* are famous examples of wool-silk mixtures. This last is a light weight dress fabric sometimes made from single worsted yarn, but in the best qualities with silk mixtures. On the other hand, in low qualities, cotton warp is substituted for the silk.

Before the advent of the artificial dyestuffs, even when a self-coloured fabric was required, it was necessary to dye the warp and weft of a wool-silk fabric separately, and when a shot effect was desired it was secured by a twill weave in the fabric, and by using two already dyed fibres of different colours. Before the advent of the direct cotton colours combinations of acid and

basic dyes were used, but now the dyer can treat the wool-silk fabric in a single bath, even to produce a shot effect.

Preparing the Fabric for Dyeing. The bleaching and other preliminary operations differ little from the procedure adopted for pure wool, with the exception that the lustre of the silk must not be spoiled. In some dye-houses the material is wrapped round a roller and soaked for about ten minutes between rollers in warm soap solution. The stuff is then re-wrapped and left so for half an hour. With very hard yarns the soaping is done on a full-width washing machine. Bleaching is done with peroxide of sodium or hydrogen, with or without a subsequent sulphuring. After sulphuring, careful bluing is necessary to get a bluish-white. With this end in view, the goods are thoroughly rinsed the moment they leave the sulphur chamber, and given a bath containing a trace of acid violet and some acetic acid, in which they remain ten minutes at the most. With a strongish bath, or after a longer time, the silk will become distinctly bluer than the wool, and the appearance will be ruined. It is of great advantage to be able to dye the piece, whether for a self colour or for a shot effect, in a single bath. Then all the grease and dirt which have become attached to it during spinning and weaving can be removed before dyeing, leaving the fabric in a perfectly clean condition. Thus no after-cleansing is required, whereas when the fibres are dyed in the yarn the goods must be cleansed after weaving to free them from dirt, and this has a deleterious effect upon the brilliancy of the colour of the finished fabric, more especially in the case of light colours.

Dyeing Self Colours. Half-wool is ordinarily dyed in the vat, but pale shades, the most difficult to get uniform, are dyed with a hand winch. It is a good plan to line the vat with calico to prevent rubbing the material on the wood, which causes streaks.

The acid dyes are ordinarily used in a simple bath with Glauber's salt and sulphuric acid. In dyeing self colours the dyestuffs may be conveniently put into two classes.

1. Those going on silk and wool equally from a boiling acid bath. A slight difference of the shade is sometimes of little importance, and at others it is aimed at to obtain a pleasing effect.
2. Those going on wool deeper than silk.

This is corrected for self colours by topping the silk with a basic dye.

The acidity of the bath and its temperature have a great effect upon the evenness of colour. The more acid the bath the more dye goes on the wool. The exact procedure varies, and no hard and fast rules can be laid down. If, however, the silk is not sufficiently dyed or differs in shade from the wool it is a good plan to leave the goods in the cooling-bath for half an hour. If more dye is added during the cooling, most of it will go on to the silk. If this does not effect the purpose, the silk can be shaded in a fresh cold or lukewarm bath with basic dye and acetic acid. The basic dye should not be added to the cooling-bath, as it will be liable to rub off. With the view of obtaining bright colours it is of great importance to dye as far as possible in old baths. Independently of the saving in time and of Glauber's salt and sulphuric acid, fresh baths never give such lively hues as standing ones, especially if the water used is not quite faultless. The saving in time is important, for every second the boiling lasts beyond what is necessary, the duller the final shade. Pink, for example, must never be boiled for more than half an hour, and hence skill is required in shading.

Pink is largely dyed with Acid Rhodamine IR and 3R in a boiling bath with from 4 per cent. to 8 per cent. of tartar preparation, according to shade. This dye, however, dyes silk much deeper than wool, so that it is mixed with Chromotrope 2R for light pink, and with Fuchsine S for bluish pink. The combined dyes can be made to give a yellowish pink by adding Orange II, which dyes wool and silk nearly the same. For pale blue, Alkali Blue is very good. It is dyed with borax and soap at from 60° C. to the boil. Then rinse well, and sour in a fresh bath with sulphuric acid. Cream is dyed with Azoflavine FF, shading with Quinoline Yellow or Orange II. Nile green is dyed with Patent Blue II and Quinoline Yellow, or, if a pure shade is wanted, with light Green SF yellowish and Quinoline Yellow, and on the hand winch, for it is difficult to get pale shades level with light green. The following are also useful dyes: Bordeaux Fast Red A7, Fast Ponceau G, Orange II, Acid Violet 4R, Brilliant Croceine, Ponceau R and 4RB, Navy Blue, Acid Violet 6BN, 5BF, 3BN, Wool Blue S, Patent Blue V, N, C, Fast Blue, Fast Dark Blue, Guinea Violet; and for deepening: Wool Green with Orange II or Fast Red. Black: Palatine Black 6B, Naphthylamine Black 4B, Wool Black GR. Add Acid Violet for blue black.

Some of the dianil colours dye wool and silk alike in a neutral salt bath at the boil. These are the various brands of Dianil Yellow, Brown, Claret Red, Blue, and Black, Dianil Orange G, and Dianil Red 4B. It will be noted that these give a good variety of shades and the bath is simply made with Glauber's salt, the amount varying with the shade desired. If the silk is dyed too light the bath is cooled down a little, and the material is worked for some time at a lower temperature.

Shot Effects. For shot effects, very familiar on gloria in umbrella and sunshade cloths, the usable dyestuffs may be classed as:

1. Those which will dye the wool almost exclusively.
2. Those which will dye only the silk.

In the case of a large number of acid colours which go readily on wool, scarcely tinting silk, the dye-bath is prepared with 10 per cent. of acetic acid and the requisite percentage of the dyestuff. The material is entered at the boil and boiled for an hour or more. The shade must be dyed deeper than the pattern, as a little colour will be taken off by the cleaning-bath necessary to rid the silk of tint. This is made with one gallon of acetate of ammonia to 1,000 gallons of water, and the goods are worked in this until the silk is clear of colour. In many instances the silk is so little tinted that a lukewarm bath of water is all that is required. The silk is sometimes dyed with a basic colour in a boiling acid bath, but there are many dyestuffs which dye silk in a cold acid bath without affecting the wool.

The following colouring matters go on the wool alone: Palatine Red, Azo Crimson S and L, Wool Scarlet 4R, Orange GG, Tartrazine, Naphthol Yellow S, Indigo Extract, Azo Acid Blue 6B, Azo Acid Black, and Victoria Violet 4BS.

Those dyestuffs which give a full shade on silk in the cold, and have little affinity for wool, include the following well-known basic colours: Magenta, Safranine, Rhodamine, Acridine, Orange NO, Phosphine Malachite Green, Turquoise Blue, Methylene Blue, Methyl Violet, Coal Black H.

Continued

QUANTITY SURVEYING

The Methods of Ascertaining and Stating the Quantities of the Various Classes of Material and Labour in Building Work

Continued from page 6349

By F. H. A. HARDCASTLE

QUANTITY surveying is a process in building enterprise which comes, in point of time, between the preparation of the drawings and specification by the architect and the making of an estimate by the builder. A bill of quantities purports to set out, in the terms usually employed in the building trade, the quantity of materials and labour which will have to be supplied, and, generally, the services which must be rendered in erecting and completing a particular building for which tenders are desired.

Qualifications. To make a successful quantity surveyor the qualities of character requisite are a love of accuracy and thoroughness and what may be termed intelligent doggedness; intellectually, a taste for analysis, for calculation, for construction, and for mechanical contrivance. The young man who hopes to attain his results by brilliant dashes has no place here.

The general education which must precede technical training includes clearness and neatness in writing—especially in the making of figures—the ability to write English with precision and distinctness, a thorough knowledge of arithmetic and mensuration, and a firm grasp of elementary mathematics, including plane and solid geometry—as taught at South Kensington—some familiarity with mechanical and—if possible—freehand drawing, and bookkeeping. With this equipment a lad of 16 or 17 will be ready to begin the study of the technical work of quantity surveying.

Squaring. Measurements in a quantity surveyor's office are calculated in duodecimals, and the first work he would there be put to is what is known as "squaring dimensions." An example follows:

EXAMPLE OF SQUARING DIMENSIONS

	31 0 24 0 6	627 0	Excavate general surface not exceeding 6' 0" deep and throw out and Fill earth into carts and cart away	13/	10 0 7½ 2½	16 11	Fir framed in floors
	153 4 2 9	421 8	2 B in mortar	[illegible]	3 6 5 3	91 9	2" deal moulded casements with cross bars and hung at bottom
	5 0	9 10	Render float and set on brick walls	2 5/	14 6	145 0	4½" × 3" fir wrought all round and framed, rebated, and twice beaded frame
	5 0 6 0	57 9	Cube brickwork in mortar	6 3/	3 7 4 4	96 10 3	¼" steel
72/	2 0	144 0	Rough cut birdsmouth		2 2 1 4	2 10 8	Planing on steel
[illegible]	0 8	100	Ends of timbers cut and pitched				

Of the three columns on the left hand side of the paper the middle one is for the actual measurements, or "dimensions," which are known as "cubes" (*i.e.*, solids), "supers" (*i.e.*, areas), "runs" (*i.e.*, lineal measurements), and "numbers." The column on the left is for "timesing" (*i.e.*, multiplying); in the column on the right are put down the results of the "squaring." The result is usually calculated to one place of duodecimals: if any remainder fall short of 6 it is neglected: if 6 or over, a unit is added. In some cases, as in measurements of steel, iron or copper, the squaring is carried to two places. The third item given above is a semicircle of 5 ft. diameter, its superficial area being set down in the third column. The next item represents a solid mass semicircular on plan and 6 ft. deep; in the third column is its cubical content. The process of "timesing" is as follows: "2/" means twice; "3/2/" means first multiplied by two and then by three, or six times; "1·3/2/" means multiplied by two, and then by three *plus* 1 (or four)—*i.e.*, 8 times. The figure "1" is said to be "dotted on"; "3/$\dot{1}$/" means three times three, or nine times. The student will do well to practise squaring dimensions (which he can easily invent) until he becomes proficient.

Abstracting. The next process in the work is "abstracting," somewhat analogous to "posting" in bookkeeping from the day-book to the ledger, and consists in transferring the results of the "squaring," together with the descriptions of all the items on the columns of dimensions, to the sheets of abstract, at the same time arranging them under the various trades to which they belong, and in the order in which they are finally to appear in the bill. Abstract paper is usually ruled as shown in the illustration, the vertical lines being rather less than an inch apart. Sometimes these lines are made by folding the paper. The chief difficulty in abstracting is in the "setting-out"—that is, in judging of the amount of space to leave for the different items. It will be readily understood that quantities of the same item occur many times in different parts of the sheets of dimensions, and one of the objects of abstracting is to collect them so as to form one item in the bill. Example of abstracting:

EXAMPLE OF ABSTRACTING

Bricklayer							Joiner
	Reduced Brickwork in Mortar			Deduct			
	Cube	1 B	1½ B	Cube	1 B	1½ B	
	420 0 26 6	1000 0 3 9 [illegible]	[illegible] 1 0 8 [illegible]	400	[illegible] 100 8 [illegible]	11 11 [illegible] [illegible]	9" 1¼" deal moulded skirting and backings 150 0 — Fitted ends 6 — Internal mitres 6 — External mitres 6 — Returned and mitred ends 2
	446 6 50 0	400 4 600	[illegible] [illegible]		100 520 10	270 0 [illegible]	
Less ⅛th ÷	396 6 44 3	3,010 8 720 10	1,151 7 44 3				
	354 3	2,290 10	[illegible] [illegible]				1¼" deal moulded and square faced framing two panels high 50 0 — Extra on ditto for panel formed as door, 2' 6" × 1' 6" including the requisite splayed and rounded fillets mitred round as stop and fixed with screws 1
	Less ⅙rd	976 7	[illegible]				
		1,313 3	[illegible]	13 rods 196 feet			

The only dimensions that sometimes undergo a change in their way to the abstract are those of brickwork. In the usual or "London" system of measurement, brickwork is reckoned in superficial "rods" (*i.e.*, 272 ft.), reduced to a thickness of 1½ brick, and the items are abstracted in a way to facilitate this. Thus 500 ft. super. of 2 B (*i.e.*, wall 2 bricks, or 18 in. thick) would be abstracted as 1,000.0 under the head of 1 B; 500.0 of 3 B, as 1,000.0 under 1½ B; 500.0 of 2½ B as 500.0 under 1 B, and 500.0 under 1½ B; 500.0 of 2¼ B as 500.0 under 1 B, and 250.0 under 1½ B, and so on. When the columns have been added up, and the deductions subtracted, the total of 1 B is "reduced" to 1½ B

by deducting one-third (or multiplying by two and dividing by three), the result is then added to the 1½ B, and the sum divided by 272. Expertness in abstracting can be attained only by practice. The following general maxims, however, may usefully be borne in mind. Do not be afraid to use plenty of paper. Be careful to put the figures exactly under those to which they will have to be added. Do not take any liberties with the dimensions. Abstract the descriptions precisely as they are given by the taker-off, and, above all, do not use any abbreviations of your own invention. Abstract all notes and memoranda as carefully as any of the dimensions. As each item is abstracted a vertical line is drawn through it on the sheet of dimensions. The abstracts are then checked, the items thereon being ticked in red, and the corresponding items in the dimensions cut through in red. This done, the abstracts are "made up"—that is, the columns of figures are cast, deductions abstracted, and then results brought into superficial yards, cubic yards, cwts., qrs., and lb., etc., as the case may be. This work, for the sake of clearness, is commonly done in violet and checked in red, or done in red and checked in black.

Billing. Billing consists in taking from the abstracts, when prepared as above described, the various items thereon and throwing them into the form of bills ready for pricing. The following is a usual order of bills. No. 1, Preliminary. This bill consists of general items not susceptible of measurement and not belonging to any particular trade, and yet important to be borne in mind as forming an element of cost - for example, provision of water for the works, sheds and latrines for workmen, office for the clerk of works, insurance from fire and making good after that or any other accident, keeping the building in repair for a stipulated time after completion, risks under the Employers' Liability Acts, and other matters extracted from the conditions of contract and the preliminary clauses of the specification.

No. 2, Excavator and Concretor; No. 3, Bricklayer and drains; No. 4, Mason; No. 5, Tiler (or Slater) and Slate Mason; No. 6, Carpenter; No. 7, Joiner and Ironmonger; No. 8, Plasterer; No. 9, Founder and Smith, Gasfitter (or Electric Lighting Engineer), Bellhanger, Hot-water Engineer; No. 10, Plumber; No. 11, Glazier; No. 12, Painter and Paperhanger; No. 13, Summary.

At the head of each bill are put the general clauses from the specification touching the labour and materials proper to the trade for instance, the nature and quality of the bricks, stone, slates, timber, steel, etc., the composition of the concrete and of the mortar, the bond of the brickwork, the gauge of the slating and the like. Of the order of the items in the various bills it is not possible to give more than a general account. Suffice it to say that, usually, "cubes" come first, then "supers," "runs," and "numbers." Within these divisions the order followed is, generally speaking, that of increasing value.

Taking-off. We now come to "taking-off," or the measurement of builders' work from the drawings and specification prepared by the architect. Here it is that the chief work of the quantity surveyor is found, and on his excellence in this will his standing in his profession rest. During the whole of the time the student is engaged in the subordinate class of work already described he should keep his eye on the "taking-off" and lose no opportunity of qualifying himself for it, spending an evening or two every week in studying building construction at classes such as are held at the various polytechnics or under the Education Department, South Kensington. It has been said that in order to take-off properly a surveyor must understand every process in every trade. This is perhaps a slight, but only a slight, exaggeration. The student will do well, therefore, to keep his eyes open and observe any building work, however trivial, that may be going on, if it is only a carpenter putting in a sash-line or a plumber bending a pipe or wiping a joint. Every opportunity, too, should be seized of going over buildings in progress, especially while the workmen are there. True, much information may (and must) be got from books, but the student should make a point of *getting into contact with the work itself*, and should not be satisfied until he has seen an example of whatever he has read of in his studies. Failing this, he will find himself at an immediate disadvantage when he comes into contact with other surveyors, and especially with builders.

General Rules of Measurement. In the following pages it is assumed that the student has become familiar with building terms.

In measuring a length, always measure from left to right. In measuring a "super"—for example, a door the first dimension taken should be the width, the second the height, and the item would be booked thus:

3 0		2″ deal moulded both sides,
7 0		four-panel door.

In measuring a "cube" for instance, a stone the first dimension taken is the length, the second the distance from front to back, and the third the height. This order should never be departed from. Walls, plastering, slating, etc., are measured as if the openings in them did not exist. These will be deducted later. In booking the dimensions care should be taken to avoid crowding. Not infrequently it is necessary to go back and insert a dimension, and a good rule is to leave room between every two dimensions for another. In writing the descriptions it is important to keep well clear of the line on the left, bearing in mind that the squaring has still to come. If any dimension is arrived at by calculation the process should be shown on the right-hand side of the column, thus:

		N 84 0
		E 43 0
		127 0
		Ddt. 10 6
		116 6
116 6		1½ B in cement. *North and East*
14 0		*walls ground floor to first.*

Generally state at the end of the description the situation of the work in question in the building. Read carefully through the specification before beginning to take off. Never put down an item that you do not yourself understand, or do not see how it is going to work, even if you can quote chapter and verse for it from the specification. The architect is entitled to expect you to consult him upon it. Settle your order of taking off, and having settled it, be exceedingly chary of departing from it even if another way seems less cumbrous in a particular case. It is often important to be able to go back, perhaps a year or two later, and follow a measurement without hesitation.

Order of Taking-off. Until some thirty years ago it was the practice to take off each trade separately, but that custom is now quite out of date, and modern surveyors, broadly speaking,

measure not a *trade*, but a *thing*, whether it happens to involve one trade only, or several. The exceptions to this rule are joinery, plastering and painting. The following order of taking-off is recommended:

Excavation and concrete foundations; brickwork; damp-proof course; external facings; internal facings; formation of internal openings and recesses; fires; ventilation; external openings; floors; stone or concrete staircases; quarter partitions; roofs; eaves gutters and rain-water pipes; internal plumbing and water supply; drains; hot-water engineering; gasfitting; bellhanging; joinery; plastering and paperhanging; painting.

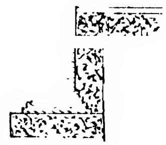
Excavation, Concrete and Walls. If the architect has not supplied a plan of the foundations it is often worth the surveyor's while to make one himself.

The first item of digging is sometimes a superficial one for removing the vegetable soil to a stated depth, say 10 in., but the general excavation is taken by the foot cube. If the contour of the site is irregular, an average depth may be got by a series of ordinates. When the "surface excavation"—to bring the level down to that of the concrete under the ground floor—has been taken, the excavation for the basement is measured, first to a depth of 6 ft., describing it as not exceeding 6 ft. deep, thence to a depth of 12 ft. (or less, as the case may be), describing it as "commencing at 6 ft. deep and not exceeding 12′ 0″ deep," and so on. The description must be worded so as to provide for any old foundations, roots of trees, drain-pipes, etc., that may be encountered. The excavation for the trenches should next be taken, first those below the basement, described as "Excavation for trenches commencing at basement level and not exceeding 6′ 0″ below same," and so on. Now, as to dealing with the earth excavated. In the case of, say, a mansion in a park, where the surplus earth can be easily disposed of, it will probably be sufficient to say of the excavation from the trenches "part returned filled in and rammed, the remainder wheeled, spread and levelled as directed." But usually, and in particular in large towns, where the removal of the earth often costs more than the digging, the portion carted away should be kept separate from that returned and filled in. A convenient way of doing this is first to measure all the earth taken from the trenches as returned and rammed, and then to take items of "deduct return and ram, and add cart away," thus:

150 0 3 3 5 6		Excavate trenches not exceeding 6′ 0″ deep, and throw out, and Return and ram around foundations.
150 0 3 3 2 0		Concrete as described, and Deduct return and ram, and Add fill and cart away.
150 0 1 11 9		Deduct return and ram, and Add cart away. *For footings.*
150 0 1 2 2 9		Ditto Ditto And Ditto *For wall.*

The area of the sides of the basement and of the trenches may now be measured for strutting and planking, keeping them separate. Next take the concrete foundations, using the dimensions of the trenches for this purpose, and not forgetting the "leg" required when a shallow trench abuts on a deep one [see sketch].

Next come the external walls, beginning with the footings, then the internal walls, chimney breasts and stacks, and piers. Great care is necessary to avoid missing any of the internal walls. A good plan is to take first all that run from left to right, and then all that go at right angles to these. The dimensions of the concrete for the external walls may sometimes be used for the brickwork.

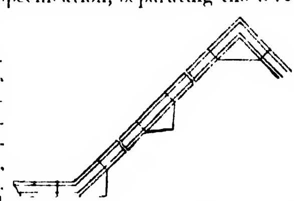


The walls may be conveniently taken floor by floor, but chimney breasts and stacks should be taken one by one, from bottom to top. The damp-proof course should next be taken from the measurements of the brickwork—as, for instance, all the one-brick walls collected and the total booked as a dimension by 9 in., and so on. Then the vertical asphalting on the outside of the basement walls next the earth as a "super" dimension, not forgetting to give the total length of the internal angles as "solid fillet at internal angle."

Any requisite steel girders, etc., to support walls on the upper floors should be taken with the brickwork, or noted to be taken later. The chimney breasts usually grow wider as they go up, and require 3 in. or 4 in. self-faced York stone corbels where they set off. Keep separate any brickwork in cement, also any brickwork hoisted more than 40 ft. above the ground-floor level, giving the stages 40 ft. to 60 ft., 60 ft. to 80 ft., and so on. All right angles are included in the price of the brickwork, but a lineal measurement is taken of all others—"birdsmouth," if internal angles; "squintquoin" if external.

External Facings—Chimneys. Measure the weathering on the tops of the chimney caps (super), next the cornices and neckings, etc., beginning with the projecting brickwork (super), and following with the cornice (lineal), as thus: "24.0 Extra on ordinary brickwork for red-brick moulded cornice, as sketch, five courses high, two square and oversailing, and three moulded." Number the mitres and returned ends, and measure the cement weathering on top. Take the general facing down to the roof line.

Copings. Take the brick copings (run), and describe as in the specification, separating the level from the raking and numbering mitres, etc. Similarly, measure the stone coping, describing the material and the labour—for instance, 64 ft. run, 12 in. by 4 in. Rubbed Portland stone coping, weathered, moulded, and twice throated (as sketch), and set and pointed in cement; 20 ft. run, 12 in. by 4 in.; ditto raking to gables.



No. 4 external angles.

No. 2 internal angles.

No. 3 fair ends with returned and mitred moulding, etc.

No. 2 kneelers (as sketch), 13 in. by 12 in. by 10 in. (labour and material).

No. 2 bonders, 10 in. by 12 in. by 10 in. (labour and material).

No. 1 apex stone, 16½ in. by 12 in. by 11 in. (labour and material).

Number the cramps as specified. Take fair raking cutting (run) to facings on both sides of the wall under the raking coping.

Cornices, etc. The brick cornices, string courses, etc., will be measured as already described for the cornices of chimney stacks. If of stone, take them by the foot run, numbering the mitres, etc.—for example,

150 0		18 in. by 12 in. Portland stone cornice, rubbed, weathered, and moulded (as sketch), and set and joggle-jointed in cement.
No. 2		Stopped ends.
No. 6		External angles.
No. 2		Irregular angles.
No. 4		Internal angles.

General Facings. The general facings may now be taken, *between* the string courses, etc., but *over* all openings—*e.g.*,

N. elevation	44	6
E. elevation	30	0
S. elevation	20	0
At break 2/.9	1	6
	10	0
	14	6
W. elevation	30	0
	150	6

150 0 28 6		Extra on ordinary brickwork for facings of best red Farehams, the joints raked out and afterwards neatly pointed with a weathered joint.

If the facings be of stone we should, instead, get an item such as the following:

150 6 28 6		Rubbed Portland stone ashlar, average 6¾ in. on bed and setting and pointing as described.

Internal Facings. Measure the surfaces of the walls faced with brick; also the limewhiting or distempering, taking the description from the specification. In the case of glazed brick facing, give the run of the internal angles as "Extra for waste at internal angles."

Internal Openings. Begin on the lowest floor, and take the formation of all doorways, borrowed lights, archways, and recesses. Example of doorway:

	3 0 7 0	1 B. deduct *Between kitchen and passage.*
	3 9 6	1 B. deduct *For lintel.*
	3 9	9-in. by 6-in. concrete lintel, including 2 in. by 2 in. by ¼ in. R.S.T. the whole length; also any requisite casing (brickwork deducted).
2/	No 5	Extra on brickwork for concrete fixing bricks, 9 in. by 4½ in. by 3 in.
	3 9 9	3-in. tooled York threshold, edges jointed, and bedding in cement.
	No. 2	Ends ditto, cut and pinned in cement.

Some surveyors here follow with the joiner's work for the opening.

If, instead of a lintel, we have an arch, we get:

3 2 9		Centring to segmental arch.
No. 1		Extra labour and waste and cement for segmental arch in cement, 3 ft. span, 1 B. on soffit, 1 B. high.

Fire. Example of measurement places:

3 0 3 0		1½ B. deduct.
No. 1		Extra to segmental arch 3 ft. span, 1 B. × 1 B. a.b. (a.b. means "as before").
5 0		2¼ in. × ⅜ in. wrought-iron chimney bar, caulked and cambered and building in by bricklayer.
3 0 1 2		2½-in. York tooled hearth, edges jointed, and bedding in mortar. *Back.*
4 6 1 6		2½-in. ditto, rubbed ditto. *Front.*
4 6 1 8		Half-brick in cement trimmer arch, and levelling in fine concrete for hearth, and centring trimmer arches.
4 6		Skewback cutting.
4 6		4½-in. by 2½-in. deal feather-edged springer.
No. 1		Filleting soffit of trimmer arch for lathing to.
No. 1		Slow-combustion stove, p.c. £3, and add setting same with the requisite bricks in mortar, firebricks, and fireclay.
No. 1		Rendering in lime and hair mortar to backs of fireplaces.
No. 1		Flue 30 ft. long, parged with cow-dung parge, and cored out at completion.
No. 1		Red terra-cotta chimney-pot, 2 ft. 6 in. high, and setting and flaunching in cement.
No. 1		Chimney-piece, p.c. £4, and add fixing in best manner with the necessary galvanised iron cramps, dowels, and cement, etc.
No. 2		Notching 2½-in. York hearth for jambs of chimney-piece.
4 0 3 6		Deduct render float and set walls, and Deduct paper at 3s. per piece.
No. 1		Making good in Parian cement to plastering around chimney-piece.

The void in the case of flues (up to 14 in. by 14 in.) is not deducted. It is left to pay for the forming of the flue.

Ventilation. Take, first, all the foul-air extracts, and then the fresh air inlets. Number the gratings, etc., and fixing, taking the descriptions from the specification.

No. 1. 14 in. by 9 in. cast iron galvanised air grating of approved pattern and building in, including forming opening in 1½ B wall, finished all round with ¾ in. Portland cement trowelled smooth, also the requisite 3 in. tooled York lintel.

The ventilators in the roof are usually taken with the roof.

External Openings. First deduct the brickwork, then take the work on the inside and afterwards that on the outside of the wall.

Example :

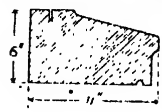
2/	4 6	1 B deduct.
2/	6 3	
		Night nursery windows (2).
2/	3 9 6 0	½ B deduct
2/	5 3 9	1 B deduct *For lintel.*
2/	5 3	9 in. by 9 in. concrete lintel, etc., a. b.
2/ 2/	No 4	Concrete fixing bricks a. b. 2/4 6 – 9 0 2/6 3 – 12 6 21 6
2/	No. 1	Window frame 21 ft. 6 in., around bedded in lime and hair and pointed in cement, the sill bedded in white lead.
2/	3 11	Centring to 4½ in. segmental soffit.
2/	3 11 4	Extra on brickwork for red rubbed and gauged arch in T.L.B., rubbers set in cement and raked out and pointed to match the general facings.
2/	4 2	Ditto, and deduct red facings a. b.
2/ 2/	9	Skewback cutting to facings (at ends of arch).
2/	4 4	Circular cutting to facings (over arch).
2/	4 2	11 in. by 6 in. rubbed Portland stone window-sill, sunk, weathered moulded, throated, and grooved for iron tongue, and setting in cement (as sketch in next column).
2/	No. 2	Fair ends with moulding returned and mitred and stoppings to weathering, etc.
2/	No. 2	Ends of sill cut and pinned to facings.
2/	No. 1	Sill bedded hollow and made up and pointed at completion.

2/ 2/	4½	Red facings as before. *Reveals* 6 3 6
2/		Deduct facings as before. 6 9

Some surveyors here follow with the joiners' work, etc., of the window.

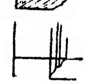
The external openings should be taken floor by floor, beginning at the bottom and sometimes front by front.

Measurement of Stonework. In the foregoing instance the facings are assumed to face of brick. When, however, the facings of the



front or the dressings of the openings are of stone, the measurement of the work on the outside is modified accordingly. It may be convenient at this point, therefore, to deal with the mode of measuring stonework, of which some general account may here be given, though the matter is too complicated to be explained with completeness. All stones not more than 3 in. thick are measured "super." Copings, cornices, string courses, plinth courses, are commonly taken by the foot run, with a sketch of the section, the mitres, etc., being numbered. Sometimes the stones are "cubed up" and described, being classified under several heads, as "cube Portland stone and all labours in plain string courses"; "Do. in moulded do. and cornices"; "Do. in moulded and rebated jambs of doors and windows," etc., accompanied by sketches illustrating the character of the work.

The most scientific mode, however, is to take the stone and the labours upon it separately. The only labour included in the price per foot cube is that needed to saw or draft it to its size, and to hoist and set it. First the size is taken as the smallest imaginary rectangular cube that would contain the finished stone, and if any *particular stone* is longer than is usual (generally 6 ft. and over), it is kept separate and called "scantling." The heading of the mason's bill should state that "the stone is measured net as set, including preliminary labours." The following are recognised labours taken by the foot super. "Back," the labour on the back of the stone, where it comes into contact with other material—as brickwork; "bed," the labour on the horizontal surfaces above and below coming in contact with stone or other material; "joint," that on the similar vertical faces at right angles to the front face (these are usually added together, the quantity halved, and described as "one face measured for two"); "sunk bed and joint," similar labour to bed and joint, but not rectangular with the adjacent faces, or rebated—as the joints of the voussoir of an arch or the sinking for a door frame (the last-named labour is sometimes kept *separate*); "circular bed and joint," the labour when convex as at the top of a voussoir; "circular sunk bed and joint," that where concave, as at the bottom of a voussoir when not exposed; "plain work," the labour on the exposed plain surface; "sunk work," that similar to sunk joint, but exposed, as the weathering on the top of a sill. Where the sinking cannot be worked without impediment (or worked "through"), as in a rebate on the outside of a window head, it is



termed "sunk work stopped." This applies also to other labours. "Circular work" is the face labour to convex surfaces—as to the shafts of columns: "circular sunk work," the like to concave surfaces as to the soffits of arch stones; "circular circular work," the labour to the face when circular both ways, as to the outside of a dome; "sunk work circular circular," that to the inside of a dome: "moulded work" is measured over the whole surface as by a fine string: "moulded work circular continuous," as to the moulded base of a column; The following are taken by the foot run: chamfers up to 3 in. wide, mouldings up to 6 in. girth, groove, throat (*i.e.*, hollow groove), joggle, and the like; stopped ends, mitres, mortises, perforations, etc., are numbered. Examples:

2/	1 2 10 5 2	Cube Portland stone and hoisting and setting as described. (*Six stones.*) *Jambs of window, south of library.* [See sketch.]	
2/6/	1 2 10	Bed (one face measured for two).	1 2
2/	2 0 5 2	Half joint.	10 2 0
2/	1 11 5 2	Plain work	10 6 1 4
2/	1 5 5 2	Moulded work.	
2/	5 2	Moulding 4 in. girth.	
2/	5 2	Groove for iron casement.	
	12 0 1 8 1 0	Cube Portland stone a. b. *Cornice of bay window adjoining.* [See sketch below.]	
	12 0 1 8	Bed.	
5/	1 8 1 0	Joint.	
5/	1 8	Cement joggle.	
4/	1 8 1 0	Sunk joint (all measured).	
	No. 6	Lead cramps and mortises as described.	
	12 0 11	Sunk work.	
	No. 8	Mitres to 11 in. splay.	
	3 0 1 9	Moulded work.	
	9 0 1 9	Moulded work stopped.	
	No. 4	Mitres to moulding 1 ft. 9 in. girth.	
	No. 4	Irregular do. do.	
	12 0	Labour carving egg and tongue enrichment p.c. per foot run, and attend carver to same.	

Floors. First take the "hard" floors, then the timber floors. Begin with the basement. Take any requisite hard core (super) describing the thickness, "well rammed and levelled for pavings," the concrete bed, the cement floating, and the tile or other pavings, to the last-named of which, if the plan be irregular, take a "run" of "raking cutting and waste." To the upper floors take any cast-iron or steel columns or stanchions, girders and steel joists. Cast-iron columns are measured up in detail (super) as metal of such and such thickness, weighted out, 5 per cent. being added for featherings, and billed as:

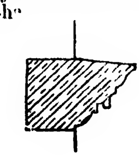
Cwt.	qrs.	lb.	
128	2	14	In No. 6 cast-iron columns and hoisting and fixing by bricklayer at first floor level.
			No. 1 pattern to cast-iron column $9\frac{1}{4}$ in. mean diameter, 13 ft. high, $1\frac{1}{4}$ in. metal, with moulded and bracketed cap and base and moulded necking.

Cast-iron stanchions are taken similarly. Steel joists are taken by the foot run, and weighted out, those 12 in. deep and over being kept separate. Compound girders are measured up in detail, and kept separate with description; this is also the case with riveted plate girders. In the last-mentioned case a percentage is usually added for rivet heads (from 2 per cent. to 5 per cent.). The shanks of the rivets take the place of the holes in the metal.

Connections of girders should be numbered and described. The steel work of a floor having been taken, next measure the flat-boarded centering, the concrete—giving the thickness—the cement floating, etc., as before described. The timber floors now follow, beginning with the sleeper walls, etc., and the sleepers, plates, and ground joists (cubed up and described as "fir and labour in sleepers and ground joists"). To the upper floors, take any steel girders, and then similarly measure the joists as "fir framed in floors." Take the ends built in, and any stone or iron corbels next flues. Take the herring-bone strutting by the foot run. Measure any sound boarding and pugging over the whole area of the floors, and add to this description "joists measured in."

Quarter Partitions. Take each piece of timber by the foot cube and describe as "fir framed in quarter partitions." Keep separate any that are "trussed," and describe the latter as "fir framed in trussed partitions." Measure the horizontal timbers first, then the vertical, then the raking. Measure the straps by the foot run, and describe as "wrought iron in straps, forged as required, including perforations and fixing by carpenter." Number the bolts.

Staircases. Here follow the stone or concrete stairs, the steps being taken by the foot run by 14 in. by 7 in., or whatever may be the extreme size, and the material, finish, and form—as whether square or spandril—stated. The labour to the ends is numbered, as "fair ends," or "fair ends with moulding returned and mitred." The ends cut and pinned are also numbered. Winders are numbered and described, the extreme dimensions being given, with sketches. Next take the landings by the foot super; similarly, the labour on the edges by the foot run, as also the "edge cut and pinned."



Number the newels and balusters, and the mortises and lead for them. Take also here the handrails, whether of metal or of wood, by the foot run, stating if "ramped" (curved in a vertical plane), "circular level" (curved on the horizontal plane), or "wreathed" (curved in two planes, as at the turn round a well hole). If the handrail be of wood, take at each joint a "heading joint and wrought-iron handrail screw, the heads, etc., let in and pelleted"—that is, concealed with wood pellets let in.

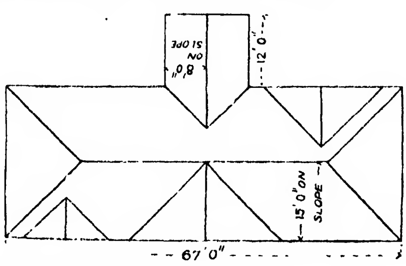
Roofs. If the architect does not supply a roof plan, it is worth while to make one yourself, or get one made. First, take the roof trusses, measuring by the foot cube each timber separately, thus: tie-beam, principals, king-post, struts; and describing as "fir-framed in roof trusses." Number the cleats for purlins, also the cast-iron shoes and heads, giving the weights and stating how many patterns will be required. Take the straps and bolts as already directed for partitions, and number the wedges and cotters, giving the weight. Take also the stone templates and heels of roof truss cut and pinned.

If the trusses be of steel, each piece should be measured in detail, and the whole reduced to weight. The item would then appear in the bill somewhat as follows:

Cwt. qrs. lb.

244 1 7 In No. 7 steel riveted roof trusses, 59 ft. span, 15 ft. rise, of 4 in. × 4 in. angle as principals, $1\frac{1}{4}$ in. and $2\frac{1}{8}$ in. diameter tie rods, $2\frac{1}{2}$ in. × $\frac{1}{2}$ in., $3\frac{1}{2}$ in. × $\frac{1}{2}$ in., and 1 in. diameter bar as struts, etc., $\frac{5}{8}$ in. connecting plates, and all fitting, forgings, and cutting, rivets and bolts and holes, and hoisting and fixing by bricklayer, the apex 54 ft. above ground-floor level.

Measure the superficial area of the slating (or tiling) with the deal battens for same, and roof boarding and felt. If all the slopes are of the same pitch, the hips and valleys do not affect the area.



The area of this roof is taken in two dimensions, thus:

2/ 67 0 15 0		Slating as described, and
12 0 8 0		2 in. × $\frac{3}{4}$ in. deal battens spaced for countess slating and well nailed; and $\frac{3}{4}$ in. deal roof boarding, English cut, closely jointed, and all splays, notchings, etc., and well nailing, and felt as described, well nailed with clouts, and including laps (measured net, as seen).

Collect the total length of the eaves thus:

2/ 25 6 =	51 0
	27 0
2/ 12 0 =	24 0
	2 6
	3 6
	20 6
	3 6
	3 3
	135 3

135 3 | Extra labour and materials to slating at eaves

From the length of the eaves may now be taken the eaves fillet at eaves (run), or eaves board (super.), and the plate may be calculated: the roof plate (cube) next, and other horizontal timbers should be taken, as purlins, ridge-rafters, and slate or other ridges; then the rafters and the ceiling joists (cube), the extra labour and material to slate verge (run), and the deal tilter thereto, the deal tilter next gable walls, etc., and the lead soakers and flashings to make watertight connection between the edge of the slate roof and the wall. Lead soakers (super and weighted) are of 4 lb. lead, one to each course of slates (or tiles), lying 4 in. under same, and going 4 in. up the walls; the length should equal the gauge of the slating, plus the lap, plus 1 in.

Number them for fixing by the slater. For secret [illegible] ab[illegible] 13 i[illegible] of [illegible] lead [illegible]qu[illegible]ed. Ne[illegible] 5-lb. lead stepped flashings, 6 in. wide, as cover (super and weighted). Lastly, the running length for lead wedging and for raking out joints of brickwork and pointing in cement to stepped flashings. All lead work is measured strictly net, with no allowance whatever for waste.

To chimney stacks take the deduction of rafters and the addition of the trimmers, etc., also the deduction of the slating, etc. Measure a 6-in. width of slating down the slopes for cuttings, and the lead work, etc., as to gables; at bottom a 5-lb. lead apron, 12 in. wide, and at top a lead gutter 8 in. wide. Let us assume that the stack is three bricks thick, etc., the gutter would then be measured thus:

2 3 8		$1\frac{1}{4}$ in. deal gutter boards and framed bearers.
No. 1		Short length of 2 in. deal rounded roll (across the gutter in the middle).
No. 2		Small 1 in. deal gussets, prepared one side for lead, and fitted and fixed at ends of gutters.
		ft. in. 2 3 Extra for roll 8 At each end 2/.9 = 1 6 4 5
		ft. in. 8 Against brickwork 6 Up slope 1 0 2 2
4 5 2 2		6-lb. lead and labour laying in gutters.

No. 2		Ends of roll bossed	2 3
		2/.6 =	1 0
			3 3
	3 6	5 lb. lead and labour laying as flashings.	
	3 3	Lead wedging to flashings, and Rake out and point flashings.	
2/	2 3	Large feather-edged eaves fillet, and Extra to slate eaves a.b.	

Next, take the hips and valleys, first the timbers (cube), then the length by 6 in. of roof boarding for cuttings, and by 1 ft. of slating for cuttings, also the length for the slate hips. Number the labours at the ends of the hips and the hip hooks at the foot. For a lead valley, super up the $1\frac{1}{4}$ in. valley board, "splayed and fitted," run the tilter on each side, and super up the lead, the length plus 6 in. at each end, and 6 in. for each lap, by (say) 1 ft. 6 in. wide.

Take the gutters next parapets, etc., in the manner already described, but measure the rolls and drips by the foot run, and at each 2 in. drip, allow 8 in. extra of lead. Take the cesspools thus:

No. 1	$1\frac{1}{4}$ in. deal dovetailed cesspool, 10 in. × 10 in., and 5 in. deep (all in clear), holed, fitted, and rebated for cover.

Super up the lead lining, and number the "extra labour, etc., dressing and copper nailing lead in cesspool," the copper cover, the lead socket pipe to carry the water to the rain-water head outside, and the hole through the wall. All the cube timber in the foregoing is described as "fir-framed in roofs." Another way is first to measure all the timbers, boarding, etc., as above, and afterwards the slating and lead work. Note particularly that the lead work of a gutter should always be carried up the slope of the roof to a vertical height of 6 in. above the sole of the gutter.

Eaves Gutters, and Rain-water Pipes. These are taken by the foot run, now generally measured net, excepting to small breaks, and around pilasters, etc. (which are numbered), the size and description and mode of fixing being given, as thus:

98 0 5 in. by 4 in. cast iron moulded eaves gutter (No. 20 in So and So's list), with rebated joints made up in red lead and two bolts to each joint, and strongly screwing to deal fascia and bedding and pointing in cement on brick cornice, including all cuttings and waste (measured net). The stopped ends, angles, outlets, and covers for same are numbered. In the case of rain water pipes the swan-neck bends should be numbered, the girth given, and the number of patterns required stated.

Internal Plumbing and Water Supply. It is convenient to include in the heading of this bill a table of the weights per yard run of the lead pipes, the pipes being classified as "waste," "service," and "main." The size of a pipe is the diameter of its bore. The price per foot run fixed includes running joints, wall-hooks or tacks, also bends, unless the pipe is 2 in. or over, in which case the bends must be numbered in addition. Number the soldered ends, also the "branch" joints, stating the size of the pipe—as in the following example:

No. 2	Extra soldered joints to 1 in. lead pipe, or,
No. 2	Soldered joints of $\frac{3}{4}$ in. and 1 in. lead pipes.

The joints to taps and unions are included with them. Lengths of pipe under 2ft. 6 in. are numbered, the number of bends in each being stated.

Fittings and Wastes, Etc. Begin with the w.c. on the top floor. Number the apparatus, giving description and including fixing and all unions and joints. Next take the soil pipe down to the drain and connect thereto, also up, as ventilator, and finish with cap, and take the hole through the wall. Take the water-waste preventer, the overflow pipe, and the hole through the wall, the flushing pipe and connection to pan. Similarly, take all other w.c.'s, urinals, etc., discharging into this soil pipe. Take the anti-syphonage pipes. Sinks, urinals, lavatories, and baths, and their wastes are measured similarly. Care should be used to take the traps if they are not included in the description of the fittings—for instance, to the lavatories. With the fittings it is convenient to measure any draining-boards, cupboards, etc., connected therewith.

Cisterns and Pipes. Cisterns are usually of galvanised wrought iron. Describe the capacity—*e.g.*, 300 gallons—the thickness of the metal, and the height to which hoisted. If the situation will not allow of a stock size being used, give the exact dimensions. Take any fir or steel bearers, the lead or zinc safe under and waste pipe from same, and the deal cover. Next, take the "warning pipe." If this passes through the roof, take a slater's number item of "perforation" through slated roof for pipe passing through, and making good, and plumber's item for a set of 5-lb. lead flashings soldered on. With each pipe that leaves the cistern take the connection thereto—as:

No.	Perforation in galvanised iron cistern for $1\frac{1}{2}$-in. union.
No.	$1\frac{1}{2}$-in. brass boiler-screw union and fly nuts and 7-lb. lead washers to iron cistern, and soldered joint to lead pipe.

From the cistern take the service pipes to the various fittings (except, perhaps, the sinks, which are now usually supplied from the "rising main"). Measure the chief pipe from the cistern on to the point where it ends, and number the soldered end or tap which finishes it. If, in its course, the pipe diminishes—say, from $1\frac{1}{2}$ in. to $1\frac{1}{4}$ in.—take at that point a "$1\frac{1}{2}$ in. extra soldered joint." Next take the stopcock on it near the cistern; then the first pipe that branches from it to its end, with all its taps and branches, complete. That branch being exhausted, pass down the main pipe till you come to the next branch; exhaust that in like manner, and so on. Having completed the pipes from the cistern (termed "services"), take the "supply pipe"—that is, the pipe from the main in the road up to the cistern—and the ballcock at the end of it. Then the stopcock near the beginning, and next, any branches to sinks, etc. If there are two or more cisterns, take one and all the pipes from it before touching the other. If iron pipes are used, the mode of measurement is much the same as in the case of lead. With the pipes take all pipe-casings (run), also holes through walls and chases.

The hot-water supply, gasfitter, bellhanger, lifts, speaking-tubes, and electric lighting follow here, and are usually dealt with by provisional sums of money.

Drains. Begin with the gulley at the point of the drain farthest from the outfall, number and describe it, with the excavation and concrete and setting, and take the stone cover. Next take the drain therefrom to the first chamber, describing the size of the pipe, how jointed, and the average depth of the trench and any concrete under or around it. Count up all bends, junctions, etc. Complete the drains that go into this pipe and this chamber, and then take the chamber. Next take the pipe from this chamber into the next, and all branches, with their gulleys, etc., and so on. Finally the pipe from the last chamber up to the sewer in road and connection therewith.

Joiner's Work. Measure the floor-boards (super), describing the material, thickness, etc. If any edge of a floor is not square with the others, take the length by 3 in. for waste. With the skirtings, chair rails, dados, and wall-linings, take the grounds, separating those that are plugged or fixed with wall-hooks across flues. Number the mitres, etc., in skirtings, and chair rails, and to dados, etc., take them by the foot run.

Staircases. First take the newels (run), numbering the caps and pendants; next the wall-strings and outer-strings (run), separating the "ramped" and "wreathed," etc. [see page 6510], then the steps, for which take the length from left to right *plus* 1″ at each end (housing). This dimension, multiplied by the width of the tread and the height of the riser added together is the measurement of a step, and should be booked thus:

Tread	11
Riser	6
	1 5

3 3		$1\frac{1}{4}$ in. deal treads with moulded nosing and 1 in. risers, tongued together, glued, blocked and bracketed on and including two strong fir carriages and prepared for cut strings—(if the ends are visible, or for close strings if otherwise). Note that if *a* is the width of the tread and *b* the height of the riser, *a* plus 2*b* should usually equal 23 in.
1 5		

Winders are measured net, thus:

3		Ditto in winders and measured net	
		6	3
		1	3
10 9		—	3
7		7	
			10 9

If the bottom step is longer and with a semi-circular end measure it the extreme length and take in addition an item:

No. 1		Extra on treads and risers as before for semicircular end with solid block and veneered front to riser without heading joint (say) 4 ft. 6 in. girth.

Take housing or returned and mitred ends of the steps; the handrail [see page 6511], number and describe the balusters, stating how fixed at ends, and measure the lathing and plastering to the soffits. Super up and describe the landings, including bearers.

Windows. Measure sashes and cased frames, the extreme width by the extreme height, and give the description from the specification. If the head is (say) segmental, add the words "with segmental head, measured square." The price per foot for this work includes the usual splayed edge on the bottom rail and the splayed edges of the meeting rails. Any further labours are extra and must be taken by the foot run. Mention in the description if weighted for plate glass, also if in two or more lights, with cased mullions. Take the run of the galvanised iron tongue and groove in sill and number the sash fasteners and other ironmongery. Take the glass, bearing in mind that parts of inches are counted as full inches; thus, $11\frac{1}{4}$ in is 1 ft. If the glass is of irregular shape, measure the extreme size and describe as "cut to shapes." Take the linings, whether of wood or cement (super if over 4 in. wide), architraves and grounds (run) the window board (super) and the deduction of plastering and paper. Casements and solid frames are taken similarly but in detail, the casements being supered and described as "fixed," "hung at side," or as the case may be, and each piece composing the frame taken by the foot run and the labours on it described.

Doors are measured by the foot super, the width by the height, and described as:

3 0		2 in. deal four panel moulded both sides door.
7 0		

"Moulded and square" means moulded one side and square the other. If a door is glazed, describe it as (say) "rebated and moulded on solid, and prepared for glass," take the run of the small beads as stop for glass (including mitres) and measure the glass.

Next take the linings (super) or the solid frames (run) and the hinges, locks and other ironmongery and architraves. Deduct the plastering and paper. In the case of swing doors measure the run of the rounded edges similarly. Space does not permit of entering into the measurement of screens and cupboards and other fittings, but the student will find little difficulty in adapting the information given above to joiner's work of this kind.

Plastering. Measure the ceilings (super), taking the description from the specification, and mentioning if panelled or coved. Take any ceiling mouldings (run), giving the girth and numbering all mitres, etc. Next the cornices, super if 12 in. girth or over, if not, by the foot run, giving the girth. Number all mitres, etc., giving the average girth of the moulding to which they belong. Bear in mind the "core" for the cornices. The smaller cornices may be in solid plaster, but for the larger ones some "bringing-out" is required, over-sailed courses of brickwork, if practicable, and, failing these, deal framed bracketing (super) of about one-third the girth of the cornice. Wall surfaces are taken super, the same dimension serving for the plastering and for the papering.

Painting. Painting is usually measured for the most part from the sheets of dimensions after the abstracting and checking have been done. This system has the advantage of giving the surveyor a final look through his dimensions, often invaluable. Measurements in painting are taken (super) "wherever the brush goes," and are classified according to the number of coats, kind of finish, whether in two or more tints, etc. Any work that will have to be done off ladders should be given separately.

The measurement of executed work follows the lines of the "taking-off" from drawings.

BUILDING *concluded: followed by* CABINET-MAKING

Group 24
PRIME MOVERS
8
Continued from page 6298

THE MODERN LOCOMOTIVE

The Boiler. Engines—Simple and Compound. Methods of Propulsion. Adhesion and Tractive Force

By JOSEPH G. HORNER

THE modern locomotive is wholly an evolutionary product, the end of which is not yet in sight. The elements of the locomotive are the steam generator or boiler, the engines, and the methods of propulsion.

The Boiler. The most essential feature of the boiler is the large number of tubes (multitubular) which traverse its barrel, and through which the flame and hot gases pass from the fire-box on their way to the smoke-box. The locomotive type of boiler is standardised on these lines—fire-box, muiltitubular barrel, and smoke-box. Though the heating surface comprises fire-box area and tube area, the first, though smaller, is much more efficient than the second. Experiments have proved that beyond a very moderate length, there is no advantage in extension of the tubes. Hence modern locomotives—that is, those of the past decade—differ from earlier ones in enlarged dimensions of fire-box, comprising a larger grate area. As the width is limited, the extension is made in length. The limit to length is that at which efficient stoking can be done. There is a type of fire-box in which increased width is obtained (the wide fire-box) by making the sides rest on the frames instead of fitting down between them. But though the heating effect of tubes is an almost negligible quantity at and near the smoke-box end, they are nearly or quite as efficient as fire-box surface close to, and for a few inches away from the fire-box. Hence the practice adopted in American locomotives and on the Great Western Railway [see **76** to **80**] of enlarging the barrel towards the fire-box end (extended waggon top). These boilers are about 7 in. larger in diameter at this end than they are next the smoke-box.

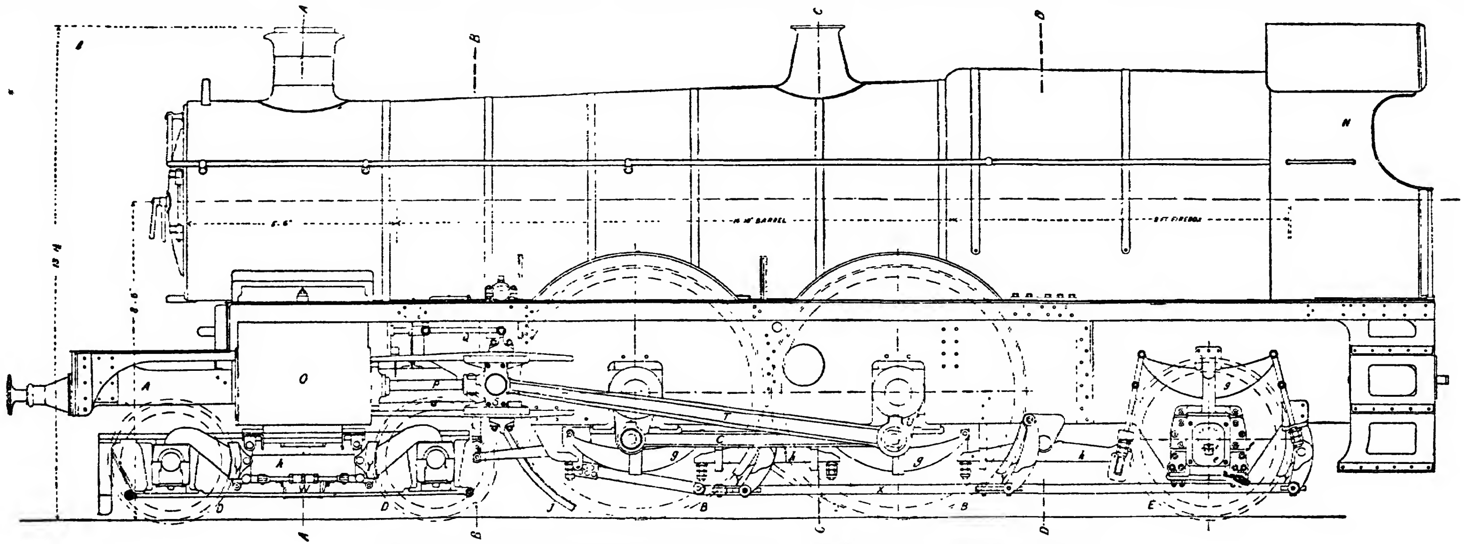
Boiler Tubes. The tubes vary in diameter and number, and barrels and tubes vary in length, and all these are variables in locomotive design. Those of all the railways have their own well-marked characteristic designs, which vary with the ideas of different superintendents. Barrels range from 4 ft. 10 in. in diameter to 5 ft. 6 in., and in length from 14 ft. to 21 ft. Tubes range from 1¼ in. to 2 in. external diameter, and number about 200. Small tubes, packed closely together, interfere with circulation, hence larger tubes and freer spacing is now adopted than formerly. The grate area of the fire-box ranges from 20 sq. ft. to 30 sq. ft. in English practice, but in the United States these areas are nearly doubled in the large freight engines and express locomotives. The total heating surface in English practice ranges from 1,500 sq. ft. to 2,500 sq. ft., which also are nearly doubled in American practice. The weight of a main line locomotive equals from 60 tons to 75 tons, and the tender another 50 tons. Some American engines weigh from 80 tons to 100 tons.

As there is no tall chimney to a locomotive boiler, there is no natural draught available to supply air to the fuel. The early locomotives had taller chimneys than the present ones. The place of the chimney, or the fan or blower, of other boilers, is taken in locomotives by the blast pipe. This is situated in the smoke-box, and enters the lower part of the chimney. The steam exhausting from the cylinders passes through the blast pipe at a high velocity, and draws after it a large volume of air. The air can come only through the fire-box and tubes. It is sufficient in volume to create a very strong draught, as efficient as that of a fan. In its simplest form, the blast pipe has a plain conical nozzle. But most are more elaborated than this, combining provision for producing variable degrees of blast, sharper or quieter, according to the rate at which it is desired to consume the fuel.

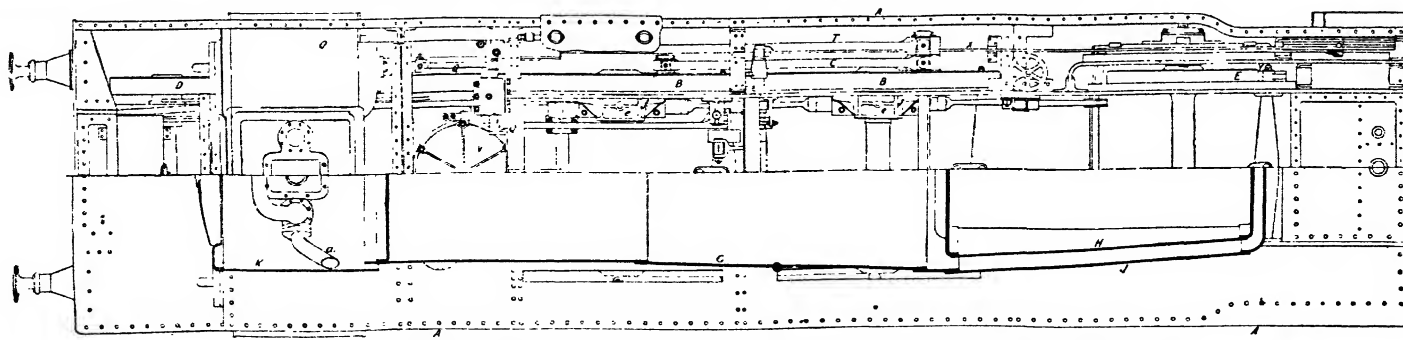
The fire-box is of approximately rectangular outlines, and comprises inner and outer portions. The inner contains the fuel, the outer is a continuation of the water and steam space. It is attached partly to the end of the cylindrical barrel, but mainly to the inner fire-box. The rectangular shape with plane faces is the weakest possible form. Yet it is the only one practicable, because of the limitations of space. The steam pressures, therefore, from 150 lb. to 180 lb. or 200 lb. per square inch, are resisted by stay bolts, which are disposed—at about 4 in. centres—so as to take the stress, and leave only as much plane plate between as will be able to resist bending. These bolts are a most important element in this type of boiler, and have been the subject of a vast number of experiments. Generally, they are screwed into adjacent plates and riveted over on the outsides. The central part is turned down as small as the roots of the threads, and with a radius, and the stress is calculated on this diameter. The roof of the fire-box is stayed with similar bolts, or more often with bridge or girder stays, of which there are numerous types in cast and wrought steel. The inner and outer fire-boxes are united through the foundation ring, and the fire-hole ring. These are forgings, or steel castings. The rivets pass through them. The smoke-box, not being subject to pressure, is made of thin sheet steel, and is riveted to the end of the barrel. It has a doorway in front, through which the tubes are exposed for cleaning. It receives the blast pipe and chimney.

The Materials of the Boiler. Formerly, all boiler barrels were made of wrought iron. This is now discarded in favour of steel. Fire-boxes are mostly made of copper. In the United States steel is commonly used. The tubes are variously made of wrought iron, steel, copper, brass, and Muntz metal, the last two being usually employed in Britain. The tubes are fixed by expanding their ends into holes drilled in the plates, which form the terminations of the boiler barrel (tube plates). The one at the front is the smoke-box tube plate, the other is the fire-box tube plate. These are about ¼ in. thicker than the ordinary shell plates, in order to give sufficient surface for holding the tubes.

The Engines. Until a comparatively recent period in the history of the locomotive, simple engines have been universal. Even after compounds were designed and tried, they made but slow headway. At present the compound engine is having its triumph on the Continent, but with various and



76. GREAT WESTERN RAILWAY ENGINE. 4—4—2 CLASS (ELEVATION)

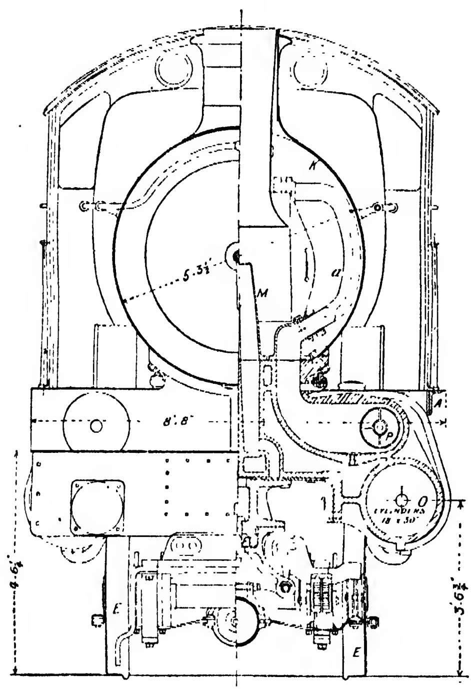


77. GREAT WESTERN RAILWAY ENGINE. 4—4—2 CLASS (BOILER SECTION AND FRAME PLAN)

diverse arrangements, and in a lesser degree, in England and America.

The Simple Engine. Not so long ago, increased engine power was sought by increase in dimensions of cylinders to the neglect of boiler power. It was not thought possible to increase the latter much, as has been now done. But at present the view taken is that ample boiler power—obtained chiefly in the enlarged fire-box and boiler end adjacent thereto—gives more than enlarged cylinders without such powers. The diameter of cylinders is limited by the conditions of the gauge. Cylinders of 18-in. or 19-in. bore are the maximum. Length of stroke is rather variable. It is usually about 26 in., but the recent Great Western engines, illustrated, have a 30-in. stroke, which gives correspondingly greater capacity.

The usual position for the cylinders in English practice is inside the frames, but in America and on



78. FRONT ELEVATION SECTION ON A-A

the Continent, outside. This affects the position of the valve gears, which must be adjacent to the cylinders, hence it seems odd to us to see the valve gears outside the frames in Continental engines. In favour of inside cylinders and gears it has been claimed that they are less liable to receive damage, and that they run more steadily than outside ones. For the latter the claim is that they are more readily examined and repaired than if located inside. There is little, if any, basis for the first, while the advantages of accessibility are unquestionable. A real objection to the inside arrangement is that dip cranks must be used, and these are liable to fracture, and numbers of failures and some fatal accidents have been traceable to these. With outside cylinders, the crank axle is straight, and the crank pins are on the driving wheels.

Simplicity is studied in locomotive engine details. The cylinders are not jacketed, but they are enclosed in the smoke-box in inside types. The cross-head guides are flat bars. The valves are of the common D type, and are main valves only, cut-off, and expansive working being controlled by link motion arrangements. There are only two types used generally, the Stephenson and the Walschäert, the first in England and in America, the second on the Continent chiefly. The Walschäert gear is, however, being taken up on some of the English lines lately. Other rivals, as the Gooch and the Allan gears, and others less known, have fallen into disuse.

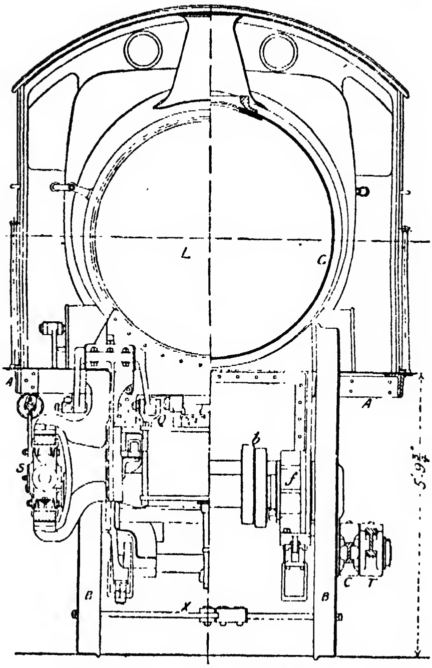
Compound Engines. All locomotive engines are of non-condensing type, because there is no room for condensing apparatus. A certain measure of economy is thus sacrificed. It seems a pity to generate steam, and, after using it once, to dissipate it into the atmosphere. Hence the fascination which compounding has had ever since it was proposed by Mallett in 1874. His was the only compound in the Paris Exhibition of 1889. The full story of the growth of the compound, if written by a qualified man, would be one of the most fascinating in the story of engineering practice. Invented in France, it has been developed in every country in Europe, and in America. In England the late Mr. Webb will be remembered as the persistent advocate of the system in the teeth of much opposition. There are now at least a dozen fairly distinct types of compound locomotives in regular use on the railways of the world, differing in arrangements of the cylinders and valves, to describe which is not possible here, and they would be bewildering apart from illustrations. The most familiar names are the Mallett, the Webb, the Henry, the De Glehn, and the Plancher. Tandem compounds, though in existence, are in a great minority, most designs having cylinders in parallel relations. There are two, three, and four cylinder compounds. Generally, engines can be worked as simple or compound. Piston valves are adopted in some recent engines. Coal economy ranges from 12 to 20 per cent.

Methods of Propulsion. These involve problems concerned with diameter of driving wheels, of the loads on them, and of tractive force. In these, as in other details, the evolutionary processes are writ large in the ever fascinating history of the locomotive. The influence of the old Watt idea that piston speed should not exceed 200 ft. per minute long affected locomotive practice. The idea held was that the velocity of the pistons should be kept down to moderate limits, or from 500 ft. to 600 ft. per minute, and speed obtained by having driving wheels of large diameter, say of from 8 ft. to 8 ft. 6 in. That explains why the older express engines drawing comparatively light loads often had large single drivers—that is, uncoupled; and the goods engine drawing heavy loads had small coupled wheels. The idea still lingers, notwithstanding some of the fastest expresses are now drawn by coupled engines with piston speeds of considerably over 1,000 ft. per minute. This also explains why, with increase in tractive force, the diameters of cylinders have not been much increased.

Increasing piston speed is as efficient as increasing diameter to an equivalent amount. If, for example, a given piston speed were increased by 50 per cent., the engine power would be augmented by 50 per cent. for the same steam pressure. But steam pressures have also grown largely. Compounding is also a source of gain. Larger boilers supply larger volumes of steam, and all these things have produced engines of greater power, so that one engine now hauls loads that required the services of two engines a few years since.

Adhesion. The two essentials which render a locomotive capable of hauling a load on smooth rails are its adhesion and its tractive force. Everyone is familiar with the slipping of locomotive wheels when starting on slippery or wet rails. This means that the greasy state of the rails overcomes for the moment the adhesion of the wheels thereto. In the early inception of locomotive engineering it was not believed that engines could haul coaches on smooth rails, and rack rails much like those employed on mountain railways were used. It was found that adhesion is secured by putting enough weight on the driving wheels, hence the advantage of the employment of big, heavy engines. The adhesion of an engine is not the same as the weight of the engine. It is less because of the slip. About one-fourth of the total weight on the driving wheels is available for adhesion on dry rails. On wet rails it may be as low as one-tenth. One-sixth is about the average proportion for ordinary conditions. Because of this loss of adhesion, the practice of sanding is necessary when starting, and when climbing inclines in wet, foggy, and frosty weather.

The weight which can be imposed on the driving wheels is obviously limited, and, therefore, with increase in weight of engine, coupling becomes necessary. But the weights on a single axle have increased largely. In 1850, six tons was the maximum load considered permissible on a single wheel, now 16 tons and 18 tons are carried. This is largely due to the substitution of steel tyres and steel rails for those of iron. But even with these loads, the increasing weight of engines has had to be distributed over more wheels, and the old types with single drivers are rapidly passing out of existence. Four, six, and eight wheels coupled are common types, and even ten wheels in some American designs. Coupling



79. SECTION ON B-B SECTION ON C-C

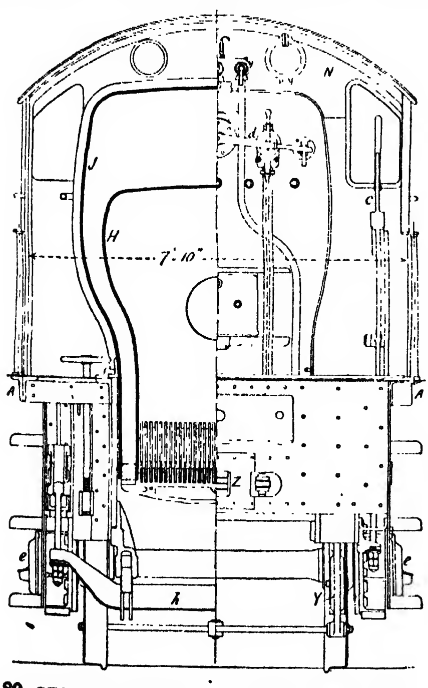
wheels means that each wheel must take its proportion of the load whatever that may be.

Tractive Force. In order that the engine shall pull its load, its friction on the rails must be at least equal to the effective pull or tractive force. If the engine wheels do not slip, then obviously any movement of the engine must draw its load along. If they slip then the adhesion is not equal to the tractive force. The driving wheels are levers, and their point of contact with the rails is their fulcrum. The tractive force is calculated thus:

$$\frac{(\text{Diam. of cylinder in in.})^2 \times \text{stroke in in.}}{\text{Diameter of driving wheel in inches}} = \begin{array}{l}\text{Tractive force in lb. for each lb. of effective}\\ \text{steam pressure upon the piston.}\end{array}$$

An important element in smooth running at high speeds is the balancing of the reciprocating and revolving parts. These include the piston and connecting rods and the cranks. They are counterbalanced in the driving wheels by the addition of weights. Many rules have been given for these, but the most exact results are obtained by trials.

The illustrations, [76 to 80] give various views of an Atlantic type, 4-4-2 class of Great Western Railway engine, designed by Mr. J. G. Churchward. The appended list of parts may be compared with the drawings which are lettered correspondingly. A, frames; B, driving wheels; C, coupling rod; D, bogie wheels; E, trailing wheels; F, bogie pivot; G, boiler barrel; H, inner fire-box; J, outer fire-box; K, smoke-box; L, tube space; M, blast pipe; N, cab; O, cylinders; P, piston, valves; Q, valve gear; R, piston rods; S, cross-heads; T, connecting rod; U, cranks; V, vacuum brake cylinder; W, ditto for bogie; X, brake rods; Y, brakes; Z, draw bar; *a*, steam pipe; *b*, eccentrics; *c*, reversing lever; *d*, regulator; *e*, axle boxes; *f*, horn blocks; *g*, axle springs; *h*, compensating levers; *j*, sanding pipe.



80. SECTION ON D-D BACK ELEVATION

Continued

Group 26 **BUSINESS MANAGEMENT** 2 Continued from page 6351	**FACTORY AND OFFICE SYSTEM** Relations Between Employers and Employes. Card Index and Loose-leaf Book Systems in Office Work

By D. N. DUNLOP

THE growth of a business is primarily a matter of organisation; organisation is primarily a matter of system; and the foundation of system is energy applied with intelligence. Many business and professional men would install systems if it were not for the false impression that they entail extra work. This error needs no other refutation than the fact that no good system is ever discarded after having been installed, but is extended and modified as business requirements demand.

What is System? System means a thorough knowledge of the smallest details of one's business, secured not by the process of doing everything oneself—there are too many details—but automatically as the result of well-directed effort and organisation. Well-directed effort on the part of each member of the staff means that each worker must know or be taught to know how and where to apply his labour with the best and quickest results. The power of executive, or of organising a business, means the power to make all the small processes of the business dovetail into each other, and work with smoothness and efficiency. Knowledge of the details can come only from a system which brings them regularly to the attention of the manager. The best system is that which enables a man to do most work with the least expenditure of time, energy, and money.

The principle underlying modern system is the elaboration of the idea of *movable units*, as exemplified in the card and loose-leaf systems, which we shall reach later in this course. The old methods differ from the new in many respects, but none is of more fundamental importance than the treatment of ledgers, books, and records of all kinds in which every leaf was a fixture, and every item on each leaf immovable. The idea of the unit, complete in itself and movable, has led to the keeping of a book of records which would have been impossible under the old order, and which enable the manager to keep in touch with the whole of the working plant and staff of his business. Daily, weekly, and monthly statements are brought to his desk to enable him to probe the efficiency of men and machines in a manner unknown in bygone days, and to trace and stop leakages in every department. Numerous labour-saving appliances and devices double or treble the output of the staff in work of all kinds, while some employes are dispensed with altogether.

Supervision. Supervision is another feature of the modern system; no officer is allowed to dodge the responsibility for misconduct or failure on the part of a subordinate whom he is in duty bound to keep up to a high standard of efficiency. Supervision must be close, constant, inexorable, but always fair, and must extend throughout the whole organisation, binding all parts together. The result is that when an order is issued by the general manager, it works its way from the centre to the most distant part of the establishment automatically, just as in a system of electric distribution when the switch is turned on. From the manager to the office-boy each employe has someone above him who knows what work he is doing, and who comes periodically to demand results.

The Dwindling of Profits. Not so long ago, within the memory of middle-aged men, the margin of profit to the middleman was so large that there was no need to institute careful methods of conducting business; guessing was near enough. But with increasing competition, large profits had to give way, and the margin became narrower and narrower. The balance-sheet still shows large gross profits in many cases, but the volume of business has expanded, and the concerns have developed and assumed enormous proportions, while the working expenses have grown simultaneously, with the result that *net* profits have proportionately decreased.

The result has been a new rivalry among business men—the pursuit and cult of economy.

The Cult of Economy. The first lesson learnt was that economy does not mean cheapness or a purely arbitrary reduction of expenses, but, on the contrary, intelligent and far-seeing expenditure and the elimination of all waste and leakage.

New methods had to be sought for reducing the outlay, while still accomplishing the end in view. Industrial and mercantile transactions involve the manipulation of material by manual, mechanical, and mental labour in order to produce a marketable commodity. Of these two factors labour is the more costly and also the more variable. Great prejudice exists in many workshops against labour-saving machinery, which is said to be a menace to the working man. This is altogether false; the effect of labour-saving machinery is entirely beneficial; it tends to lessen the cost of products and to raise the price of labour.

Cost. The business man must know to a fraction of a penny what everything costs him. A cost system should provide:

1. Efficient means of collecting all the data necessary for drawing up statements of detailed and total cost.
2. Means of affording comparisons on all manufactured products, in order that the manager may have the opportunity of analysing the comparative cost of any given job with that of previously executed jobs, and with the estimates and tenders for contracts.
3. An exact account of the work performed by every employe on the pay-roll during every hour charged therein.

By means of these records, collected on separate cards, the general manager obtains incontrovertible testimony as to the efficiency of man and plant.

A modern cost system should keep the following aims in view:

1. To lessen the cost of production.
2. To determine the cost of products collectively and in detal.
3. To fix the sale price of every article on an absolutely safe basis.

The Factor of Labour. The following are some of the means of promoting this special quality of labour.

1. Discipline and justice.
2. Cultivation of good relations between employer and men.
3. Promotion of moral and physical well-being.
4. Co-operation in the business management.
5. Participation in the profits.
6. The encouragement of *esprit de corps.*
7. Offering facilities for the acquisition of technical and scientific knowledge.
8 Inviting suggestions for improvements in machinery or processes.

It must be remembered that the employer who gives his men nothing but bare wages can expect nothing from them but so many hours' work put in. The manager must find the secret of enlisting intelligent and sympathetic co-operation.

Co-operation is effected by means of committees formed in all departments from superintendents and foremen and from employes drawn from the ranks, on account of their fitness to serve on the committee, their sense of fairness and the esteem with which they are regarded by their fellow-workmen. The meetings of the committee are held daily or weekly during the lunch hour, or at the close of the working day at the expense of the firm; their business is to report on the work and organisation of their department, and to make suggestions and discuss complaints and grievances. Committees are formed to look after sanitation and cleanliness, advertising sales, shipping, repairs, office details, etc. The employes get to feel that the business is "ours," and they become imbued with a strong feeling of *esprit de corps*, or common spirit of devotion, sympathy and enthusiasm combined with jealousy for the honour of the body as a whole. Many firms provide suggestion and grievance boxes kept locked, into which the men drop slips of paper, duly signed, containing suggestions, and these are daily collected by the manager's secretary and taken direct to the chief's office where they receive immediate attention.

Many employers have found that the encouragement of personal cleanliness and neatness at the works by providing baths, spacious lavatories, and clothes lockers for the men had a beneficial, effect on the workmen's homes and family life, for the self-respect thus engendered at the works refuses to tolerate slovenly habits and dirty, untidy homes. The sound discipline and high moral tone, too, is likewise reflected in the home life of the workmen. The cost entailed by these methods of management is a sound investment which is more effectual than many bonus and premium systems, and appeals to man's nobler nature.

The Labour Department. One of the most difficult problems which confront the business manager is the organisation of labour on a basis fair to master and men. The system adopted cannot be too simple in its working, but once installed it must be rigidly enforced.

The system we would here suggest to managers who wish to improve their organisation falls into three sections:

(*a*) The labour department.
(*b*) The timekeeping system.
(*c*) The routine.

In a large factory employing a large number of hands it is essential that labour should form a separate department under the direction of a special manager. His duties are to organise this department, to create a labour policy for the firm, to study labour questions, treat with trade unions, act as court of appeal in all labour troubles in the works, to frame rules and regulations, to impose fines and award prizes.

The Executive. His executive comprises employment agents for office, factory, and sales department, who devote their time to the selection of employes, to their training, discipline, promotion and dismissal. His right-hand man, the superintendent or buffer, plays the part of mediator between chief and men; he wins the confidence of the men, having no authority to promote or dismiss; he hears complaints and suggestions, looks after the well-being of the men. organises clubs, co-operative schemes, and recreations and fosters *esprit de corps.* The labour manager receives all data dealing with labour and the cost of production, from which he is able to study the efficiency of his army of workers, and to note the individuals who distinguish themselves and are fit subjects for promotion.

The employment agent prepares the personal records of employes, indexed by names, which comprise essential information concerning physique, character, ability, previous berths and records, reason for leaving, rate of pay, increase, promotion, quality of workmanship, complaints duly substantiated after full inquiry, special services rendered.

Three Classes of Industrial Labour. Industrial labour is divided into three classes:

1. *Productive labour*, which converts raw material into a finished product.
2. *Department non-productive labour*, essential to the productive labour, while not producing anything itself, such as foremen, oilers, sweepers, truckers, etc.
3. *General non-productive labour* necessary for the operation of the producing department, but entirely outside its jurisdiction, such as labour of the office, the sale, advertising and shipping departments, timekeeper, engineers, firemen, etc.

All three kinds of labour must figure in the cost, the sum total corresponding to the pay-roll for the same period. Every product must be made to bear its own share not only of productive labour, but also of both classes of non-productive labour.

Timekeeping System. The first aim of a modern timekeeping system is to account in detail for every minute of time charged in the pay-roll, and to see that this is accurately distributed among the articles produced; second in importance is the elimination of all clerical work from the factory departments.

The workman has two kinds of records to keep, for which cards are provided: (1) The *attendance* or *day* time card, showing the time at which he enters and leaves the works; and (2) the *job cards*, showing the exact time spent over each operation in the workshops throughout the day.

Mechanical Recorders. Mechanical recorders are used as substitutes for clerical work. On entering the works, the workman drops his card into a slot, presses a lever and picks his card out of a receptacle. The exact time in hours and minutes according to the clock on the face of the recorder is found registered in the space on the card allotted to him for the morning or afternoon of the proper day of the week; on leaving the works for the dinner hour, and finally at the end of the day, the simple action is repeated. The men, who are at once made to understand that they are paid solely for the time thus recorded on their cards, take care not to omit to register on entering and leaving the works. An automatic recorder or a calculagraph is placed in every workshop under the new regime, and the

foreman on receiving a completed job sees that the workman registers on his job card before he hands him the new work.

Keeping Records. In every business there are innumerable records of transactions, documents, lists, etc., which must be kept for constant reference; the problem is how to file and index them so that they are easily found when wanted. Experience teaches that any method which involves turning over the folios of ledgers, untying tapes, unfolding wrappers, extracting from envelopes, all tend to limit the utility of the data in question. The card system of filing and indexing solves the problem. Its watchwords are *mobility* and *get-at-ability*; it is based upon the rise of one or many series of cards, uniform in size, ruled, and printed according to the nature of the matter to be indexed, and arranged vertically on edge in trays or drawers. The cards are kept from slipping by an adjustable sliding block or follower, and are secured by means of a rod passing through a perforation in each card which, when bolted or fastened, prevents their removal. Guide cards of various colours, having indexed projections, are distributed among the cards to define certain sections and facilitate identification, while for sub-indexing, the smaller tabs on the cards give various clues alphabetical or numerical. The trays and drawers can be obtained singly or in an infinite variety of combination, in cabinets to suit the requirements of all. Expansion, which is one of the most valuable features of the system, is provided for by building up the cabinets in sections, which can be added as they are required. The essence of the whole system is that each card forms an independent unit, devoted to one name only; it can be removed to another series at any moment, according to its special significance, without leaving a gap or being considered an intruder in its new position, where it may be as readily found as before.

Decimal System of Indexing. For the purposes of an index, with its innumerable divisions and subdivisions, a numerical application of the card system has been found to save much time, as, for instance, in collecting and classifying the material for illustrated catalogues, in filing technical literature, photographs, cuts, blue prints, etc. The decimal system is the only one capable of keeping pace with proclivities for expansion of the card index, while remaining intelligible and self-evident.

As an illustration, let us take electrical engineering, which is classified among the useful arts, 600. To mechanical engineering is assigned 621; to electrical engineering No. 621·3. In group 621, the three after the point is given up entirely to electrical engineering, and may be extended indefinitely as occasion demands; 621·331 stands for electric railways. The whole system is worked out in Dewey's book, and a very complete index gives a clue to the corresponding numbers. Any firm, however, can form its own numerical sub-sections. For instance, the electrical railway section might be worked out thus: underground and elevated railways, 621·3311; three-phase, 621·3312; single-phase, 621·3313; mono-rail, 621·3314, etc. Or, again, by analogy, the decimal system can be employed in its entirety for any one business. It is evident that the use of the decimal system in indexing necessitates a key made alphabetically by an intelligent and responsible member of the establishment. With the key at hand, a moderately sharp office-boy can find the reference required in a moment. Guide cards and alphabetical tab-cards can, of course, be used in combination with the decimal system for subdivisions.

Adaptation of Decimal System in Engineering Works. In engineering and other industrial works this system may be adapted with excellent results to the nomenclature and classification of machines made, used, or of other products of the factory. It is a good plan, in grouping them, to allot 100 for each group, whether there be few or many machines in the group; memory is thereby assisted and expansion made possible without re-classification. For example:

1 to 99, planes, milling machines, etc.
100 to 199, drill presses, boring mills, etc.
200 to 299, turning and turret lathes, etc.
300 to 399, slotters, fixing machines, etc.
400 to 499, saws, cutting machines, etc.
500 to 599, oil separators, scales, electric cranes.
600 to 699, engines, motors, air compressors.

By adding a point and figures to the right, numbers can be assigned to parts, tools, and accessories of each machine.

The same system applies to the machines of the workshops for keeping machine records, and computing the machine rate.

The numbers, once allotted, follow the machines or products throughout their life in the factory, and represent them on all records. If the classification be used for the manufactured products, each drawing, pattern, casting, and, later, the part itself, should bear this number stamped upon it for the purpose of identification. Each number has a card on which all information respecting the part, such as specification, cost, percentage of floor space, insurance, interest, depreciation, the hourly machine rate, etc., is compiled and kept for reference.

Endless applications of the system will suggest themselves to those who have once tried it. For business houses, the decimal system recommends itself more especially for indexing the literature, correspondence, drawings, plans, photographs, etc.

Vertical System for Correspondence. The vertical is the ideal system of filing correspondence, enabling any subject or name to be referred to without delay, and preserving documents in perfect condition. It is nothing but the card system applied to letters by substituting folders for cards. Guide cards with index tabs project above the folders (made of strongest manilla), and may be filled in alphabetically, numerically, or geographically. By means of these guide cards, the folders can also be subdivided into subjects. A separate card index is required when the numerical system is used, to act as key to the numbered folders. Each card may bear entries of the dates of letters received and written, which often saves time in reference, rendering unnecessary any further quest in the correspondence cabinet. Separate facts, which it is desirable to record for the sake of their own importance, can be picked out of the correspondence by a boy or girl after they have been underlined in blue pencil by the chief of the department, and filed in other card indexes for reference under different heads, such as: quotations, complaints, orders, inquiries for articles not in stock, etc. Carbon copies of replies should, of course, be filed in the same folders as the original letters to save time in reference.

With a wider experience of the card system has come an extension of its scope, and many ingenious little devices are added from time to time, which considerably increase its utility. Movable tabs, mounted on a clip, are extensively used for the purpose of rapid identification, or for sub-indexing.

It is frequently necessary to keep several kinds of records in one tray or drawer. In order to distinguish them, a code of signals may be used which renders each set quite distinct. There are several ways of doing this besides the above:

1. By using cards of different colours.

2. Another method of coding the cards is to stain the top edges with coloured inks, or to make rows of dots along the edge at regular intervals, the same for all cards. As the ink can be easily scratched off, re-classification does not entail re-writing on new cards.

3. Similar notches can be cut on the top edges of the cards. When they are in place in the drawer, a line is ruled along the tops from front to back at certain intervals. Each of these lines produces on each card edge a dot, so that the edge of each card has on it the same number of dots at equal distances apart. Notches can be cut at any one of these dots to denote a certain thing.

The Memory Tickler. This is another instance of the utility of the card system. Every business or professional man, whether his place is at the top or the bottom of the ladder, needs some means for keeping him in touch with matters which require his attention punctually at definite times, or which may have to be postponed. A drawer or tray with guide cards for every day in the month, and every month in the year, is the best reminder. In front of the guide, cards may be used, folders or cards only; into the folder may be dropped slips of paper, visiting cards—anything that will serve to call up the matter which must be attended to. If any important function be postponed, the memorandum is filed on ahead, with the certainty that on the proper day it will receive attention. Every morning, the first duty after opening the mail (or perhaps even before) is to look through the *tickler* for the day, and lay out the day's work in accordance with its records. When making a promise, the date should at once be *tickled* one or two days before the fulfilment; it is a sure reminder. Manufacturers use the tickler with admirable results in turning inquiries into orders by automatically indicating the proper date at which an inquiry should be followed up if no order has come.

The Information Drawer. Business and professional men are for ever coming across useful scraps which they collect and store up for future emergencies. These scraps, valuable as they may be in themselves, are worse than useless unless you can put your hand upon them at once.

The information drawer is a catch-all for jottings, slips, cuttings, memos, etc., and is worth its weight in gold. Here, all transient, fleeting ideas are instantly anchored. The filing may be done in front of guide cards, indexed with a subject, and containing on its face and reverse a list of the records filed; or else folders may be used for each letter of the alphabet or for any subdivision that may be desirable, and they can then be filed in the usual way. The latter is the simpler system, and the best adapted to small needs.

Revolution in Office Methods. A complete revolution has indeed taken place in office methods since the advent of the card and loose-leaf systems. The introduction of the loose-leaf into business is no fad which will presently give place to some other; its wonderful possibilities have already obtained wide recognition all over the world. The basis of both card and loose-leaf systems is the ingenious principle of the independent mobile unit, each leaf or card being allotted to one person or account alone.

Advantages of the Loose-leaf Ledger. Here are a few of the reasons why this system is rapidly supplanting all others:

1. The loose-leaf is the only known device for preserving a perfectly independent record.

2. It allows all extraneous matter or dead accounts to be removed to the transfer file.

3. It renders the accounts elastic, obviating all difficulties about giving a customer a quarter-page when he should have had a half, doing away with *double double* to utilise space. The loose-leaf adjusts itself to every kind of account book and ledger: it is immaterial whether there be one item or a thousand.

4. The loose-leaf ledger is perpetual; once opened it remains open. When business dealings with a customer cease his account leaf is removed to the transfer ledger; should the business relations be resumed, all there is to be done is to return the account leaf to the current ledger. There is no need to hunt for old accounts through four or five ledgers, and perhaps five or six folios in each ledger. All the accounts are found together in the file.

5. Both sides of the loose-leaf can be filled up to the last line, while with bound books about 25 per cent. of the space is wasted.

6. The use of the loose-leaf ledger saves no less than $33\frac{1}{3}$ per cent. of the bookkeeper's time. At regular periods, the file pages and balanced accounts are removed to the transfer ledger. The dead accounts having been eliminated, striking a balance is an easy matter, and there is no danger of overlooking an open account.

7. No written index is needed, for the loose-leaf ledger provides an automatic indexing arrangement, the pages being filed in alphabetical order, as they would be in a directory, with tabs indicating the subdivisions of the alphabet. The most difficult of all bookkeeping errors to detect is that of posting items to a wrong account; but as the accounts in the loose-leaf ledger follow one another in alphabetical order there is less liability of falling into errors of any kind.

The Transfer Ledger. A characteristic of loose-ledgers is the separation of active and dead accounts. The current ledger contains all active, and the transfer ledger the suspended or closed (dead) accounts, the latter, as well as all filled pages, being eliminated and transferred after the monthly or weekly balance, so that the bookkeeper has to deal with only current items, while the whole of his previous work is kept accessible and clearly indexed. This entirely obviates the bi-annual transfer, and keeps large accounts of several pages per month or year always together in one place, thereby reducing the labour of going over an old account.

At the time of the trial balance all congestion of work is avoided, and at the same time the results are rapidly arrived at by dividing the ledger among any number of clerks working simultaneously. A rule should be made in the office that no transfer of closed accounts or filled pages may be made from the current ledger until after the monthly or weekly balance has been made. Firms usually begin by drawing up monthly balances and statements, but they very soon adopt the plan of weekly or even daily balances when they find how easily the system works, more especially if they happen to have a tabulating or adding machine.

The best practice in accounting with loose-leaf ledger is to post from direct charges by what is known as the Bill and Charge system. A lad arranges the charges beforehand in strict alphabetical or numerical order in accordance with the

scheme of the ledger. As it is inadvisable to include more than 500 accounts in one ledger, the alphabet is divided into four or five sections, each in a binder. When posting, you begin at the beginning of the ledger, and work straight through to the end of the last ledger; you will then have come to the end of the charges and will not have had to consult the index once during the whole process. Bookkeepers and accountants will readily understand what a vast saving of time is thus effected; there is besides an economy in the cost of labour which is one of the valuable features of the new business methods—the accomplishment of part of the bookkeeper's work by lower-priced help.

In order to avoid interruption of work on the ledger and waste of time, a temporary holder with a spring back is provided, having a capacity of 50 sheets to 100 sheets for the reception of new accounts or transfers which come in during the day. The principle of the loose leaf applies equally well to all the other books used in accounting, such as the cash book, journals, cost books, bills receivable and bills payable; purchase, order, and invoice books.

Loose-leaf Cash Book. In the loose-leaf cash book the ruling of the leaves and distribution of the accounts can be made to conform to the practice of the firm. The advantage of this form of cash book lies in the fact that receipts and disbursements are handled separately on leaves of two different colours, every line of which can be utilised; there may be in a month or a week ten leaves for receipts and only two for disbursements or vice versâ. The question of safety, should it be raised against the loose-leaf cash book, may be thus disposed of: the loose-leaf cash book should be paged just the same as the bound book. The cashier uses the leaves consecutively, and if a leaf be spoiled or torn it must be left in its place as though it had been used. The cashier must be made responsible for every leaf of his book; any tampering with it by extracting leaves would, therefore, be easily detected. The current cash is carried in a spring-back holder and as soon as the balance has been brought forward and the posting completed, the leaves are removed to a permanent binder, and so arranged that the receipts follow each other from week to week and month to month. The disbursements are kept to themselves behind a division leaf tabbed "disbursements" or in a separate binder. This cash book proper is stored in the vault or safe, and is no longer accessible to any not authorised by signed requisition to consult it.

Loose-leaf Invoice and Purchase Book. These possess the unique advantage of never becoming filled. By means of a scheme of indexing, they may be made to serve as purchase ledgers, showing at all times the accounts payable. The bills of each firm are filed in succession, so that reference to old accounts is a simple matter. The invoice book, in spite of being permanent, does not become cumbersome, for as soon as accounts are paid, they are transferred to another binder kept for reference only. The bookkeeper can post from this book direct without additional entry, and the *accounts payable* need no other proof of accuracy than the Purchase Record.

A simple form of leaf for this book contains the following columns—date, number, from whom purchased, amount of bill, discount, department, rebates, O.K.'s, date received, date paid, amount, remarks

The Price Book. The loose-leaf system has sounded the knell of the consecutively printed price book. The prices of goods are printed on one side of the paper and well spaced out, so that each item can be cut out, dated, and pasted in the loose-leaf price book. As each entry, as well as each leaf is independent, any line of prices may be charged without affecting the balance of the book, or necessitating revision and reprinting; the new entry is simply pasted over or at the side of the old one. For goods which fluctuate in price, the system is invaluable, as changes in price can be compared *on the same sheet*, each line of goods in this case having a page to itself.

Revolution in Rulings. The facilities afforded by the system for special rulings in loose leaves has led to a number of changes in ruling. The most notable and practical is the centre ruling for debit and credit columns divided by a balance column. The advantage of this balance column in the ledger lies in the possibility it affords of bringing down the balances in pencil at the end of the month or calling them out to the adding clerk, if the firm possess an adding or tabulating machine. It frequently happens that balances are obtained without duplicating the figures. Balancing in sections is also extensively practised and many bookkeepers handle their work so that they are practically always in a state of balance.

Double-double Abandoned. It does not seem practical to use a *double-double* ruling in loose-leaf books under any circumstances. The argument adduced in favour of its use—which is, to avoid more frequent carrying forward of totals or balances—is a fallacy in the case of the loose-leaf ledger, for it is no more troublesome to carry forward a balance to the succeeding page on a single leaf than to the second section of a double-double page. The use of double-double ruling either necessitates a very wide page and cumbersome ledger or very narrow columns for posting, both of which are inconvenient. With the loose-leaf accounting books as many leaves as are necessary for an account may be provided without trouble or reindexing; there is, therefore, no longer any advantage in using double-double in order to provide extra posting space on one page. It is no longer necessary either to have such long ledgers, running sometimes from 24 in. to 30 in.; with the loose-leaf ledger the $9\frac{1}{4}$ in. by 11 in. page or the 11 in. by 11 in., which allows a line for each day of the month and a few extra lines, is found to be sufficient even with large business houses.

The Binders. As the loose-leaf books do not need to be renewed like the bound books, new leaves alone being required, the binders are made very durable and strong with a capacity of from 500 to 1,000 leaves (2,000 pages). The leaves are punched with slit holes to allow of the leaves springing or slipping round the posts at any point; the book can thus be opened wide, lying quite flat so that the leaves are easily manipulated. It is impossible to extract a leaf without tearing it, unless the binder is unlocked. Leaves are just as securely held whether there be few or many. The binders can, therefore, be enlarged by the bookkeeper up to about 6 in., which accommodates 1,000 leaves, and makes as bulky a volume as can be conveniently used. So-called self-indexing features have been devised for the improvement of the bound ledger, but their utility is always restricted by their finite nature and inelastic limitations; they cannot compare with the loose-leaf book, *the only ledger which will index alphabetically in correct sequence for different terms* by means of its interchangeable leaves.

Continued

Continued from page 6384

ITALIAN

Continued from page 6380

By Francesco de Feo

VERBS

The Subjunctive in Principal Propositions. In addition to what has been said as to the use of the subjunctive in subordinate propositions, it must be observed that this mood is also used in principal propositions, with the following meanings:

1. Command and exhortation; in this case those persons are used which are wanting in the imperative, as: *Venga, venga colui, so io come ricèverlo,* Let the man come, I know how to receive him.

2. Wish or imprecation, as: *Iddio ti guidi e la benedizione di tuo padre t'accompagni,* May God guide thee, and may the blessing of thy father accompany thee.

3. Supposition, as: *O fosse perfidia, o fosse puro caso, il fatto sta che per seguire il suo consiglio ci trovammo ridotti a mal partito,* Whether it was perfidy or mere chance, the fact is that, in consequence of following his advice, we found ourselves in a bad position.

4. Doubt, as: *Che ábbia torto io!* It may be that I am wrong!

5. Condition, regret, reproach, as: *T'avessi incontrato prima! quanto tempo avrei risparmiato,* Had I met you before, how much time I would have saved.

6. Concession, as: *Abbia tutti i difetti di questo mondo, per me è un galantuomo,* He may have all the faults in the world, for me he is an honest man.

Tenses and their Use. The present tense represents a fact or an action as happening at the very moment of speaking, as: *Cammino,* I walk, or I am walking; *piove,* it rains, or it is raining.

The present is also used:

1. To indicate anything that happens in a period of time not entirely elapsed, as: *Questo mese tutto mi va male,* This month everything goes badly with me.

2. To indicate facts which are always true, as in general statements and proverbs, as: *Dimmi con chi vai, e ti dirò chi sei,* Tell me what company you frequent, and I will tell you who you are.

3. Instead of the past tense, in animated narration, and it is then called the Historical Present, as: *Il giorno dopo entra in càmera, ma non vede nessuno,* The next day he enters the room, but he sees no one.

NOTE. Instead of the historical present, an historical infinitive is sometimes used, as: *Ed ecco verso noi venir per nave—un vècchio bianco* (Dante), And lo! there comes towards us a hoary old man in a boat.

4. Instead of the future, when we wish to express a fact with emphasis or resolution, as: *Se torno a nàscere!* If I am born again!

The imperfect represents a past action, but as a continuous one. It is used:

1. To indicate something not yet entirely accomplished, when something else happens, as: *Quando egli entrò io scrivevo,* When he entered, I was writing.

2. Instead of the past, and it is then called the historical imperfect, as: *Un mese dopo, la poveretta moriva* (for *morì*), A month after, the poor woman died.

3. Instead of the present, as a slightly less direct form, used for the sake of courtesy, as: *Arriva in tempo, volevo domandarle una cosa,* You arrive in time, I wish to ask you something.

The present of the conditional is similarly used, as in English: *Vorrei domandarle,* I should like to ask you, instead of *voglio domandarle,* I want to ask you. So also *non saprei,* resembling the English "I could not tell you," instead of *non so,* I do not know.

4. Instead of the perfect of the conditional, especially with the verbs *potère, dovère, bisognare,* as: *Potevate dìrmelo* (*avreste potuto dìrmelo*), You could have told me; *Non dovevate farlo partire* (*non avreste dovuto*), You ought not to have let him go.

The past definite (*passato remoto*) indicates a fact that happened in the past, having no relation with present time, as: *Quando ci vide, fuggì,* When he saw us, he ran away.

The past indefinite (*passato pròssimo*) represents a fact not long ago passed, or having some relation to the present, as: *Perchè non siete venuto stamattina?* Why did you not come this morning? *Non vi ho visto tutta la settimana. Dove siete stato?* I have not seen you all the week. Where have you been?

NOTE. The student should observe that the Italian *passato pròssimo* can be used to represent a more distinct past time than the English perfect compounded with "have"; as: *L'ho veduto l'altro giorno,* lit. I have seen him the other day.

The pluperfect indicates a past action anterior to another action also passed, as: *Non seppe repètere una parola di quanto gli avevo detto,* He was not able to repeat a word of what I had been telling him.

The future tense indicates an action that is yet to take place, as: *Ti scriverò,* I will write to you. It is also used:

1. To express a command or an exhortation, as *Domani vi leverete alle sette,* To-morrow you shall get up at seven; *Lei mi permetterà,* You will allow me.

2. To express a supposition or a probability, as: *Chi è? Sarà mio fratello,* Who is it? It will be my brother (more usually, It may be, etc.).

3. To represent a shade of uncertainty, as: *Avrò torto, ma non posso fare altrimenti,* I may be wrong, but I cannot do otherwise.

The future perfect (*futuro anteriore*) indicates that something takes place previously to a future event, as: *Quando avrò finito glielo mostrerò,* When I (shall) have finished, I will show it to you.

Like the simple future, the perfect future may also be used to express a conjecture, as: *Come va che il suo amico non viene? Avrà perduto il treno,* How is it that your friend does not come? It may be that he has lost the train.

INTERJECTIONS

Interjections, strictly speaking, are not real words, but only sounds, expressing a sudden emotion, as joy, grief, surprise, contempt, etc. The number of real interjections being very limited, contrary emotions are often expressed by the same sound, the meaning of which is modified by a mere inflection of the voice, or by a gesture accompanying it.

Certain verbs, adverbs, and nouns are also used as interjections, as: *sta! bene! bravo!*

The following are the interjections most frequently used, with the meaning they generally have:

Calling: *ehi! ohe! olà! 'ss!*
Doubt: *mah!*
Grief: *ahi! ohi! ah! oimè!*
Incertitude: *uhm!*
Negation and disdain: *oibò! poh!*
Surprise or wonder: *ah! eh! oh!*
Threatening: *ehm!*
Vexation or irritation: *ih! ah!*
Weariness or impatience: *uh! aùff!*
Wish, desire: *magàri! deh!*

Of the verbs, adverbs, nouns, and other expressions used as interjections, the commonest are:

abbasso . . . ! down with . . . !
addio! good-bye!
aiuto! help!
al fuoco! fire!
all'armi! to arms!
animo! cheer up!
arrivederci is the French *au revoir*
badate! take care!
bella! capital!
bene! well!
bravo! bravo!
buono! good!
che! what!
che peccato! what a pity!
chi va là? who goes there?
davvero! indeed!
diavolo! diamine! per dince! the deuce!
dio mio! dear me!
eccomi! I am coming; yes, here I am
evviva! hurrah!
evviva . . . ! viva . . . ! long live . . . !
fuori! be gone!
guai! woe!
guardate! behold!
orsù! come on! courage!
piano! gently!
possibile! veramente! good gracious!
su! su! come along!
vergogna! shame!
via! eh via! nonsense!
zitto! silence! hush! etc., etc.

Adjectives, as *bello, buono, bravo, zitto,* also when used as interjections, agree in gender and number with the person to whom they are referred, as: *brava!* (to a lady), *brave!* (to several ladies), *zitti* (to several gentlemen or to gentlemen and ladies), *belli!* (admiring pictures, for instance), etc.

Exercise LVI.

1. Vergogna! alla vostra età fare una cosa simile. 2. Ehi! facchino, qual'è il treno per Nàpoli? 3. Viva il Re! viva la Regina! 4. Che peccato! hanno rovinato tutti i fiori. 5. Piano! piano! non vedete che in questo modo romperete tutto? 6. Ahimè! sono rovinato; non so che cosa fare. 7. Badate! c'è un gran fosso nel mezzo del giardino. 8. Che bella mùsica e che buoni artisti! Bravi! bis! 9. Su! non bisogna pèrdersi d'ànimo; il diàvolo non è così nero come si dipinge. 10. Dio mio, con questi ragazzi c'è da pèrdere la testa! 11. Aiuto! al fuoco! le fiamme minàcciano un depòsito di petròlio. 12. Ehi di casa! buona gente, dàtemi allòggio per questa notte. 13. Bella questa! voi avete rotto lo spècchio, e volete ch' io lo paghi. 14. Ih! che fracasso! non è possibile dormire. 15. Auff! che noia; andiamo via.

Key to Exercise LVI.

1. Shame! at your age to do such a thing. 2. Hi! porter, which is the train for Naples? 3. Long live the King! Long live the Queen! 4. What a pity! they have spoiled all the flowers. 5. Gently! gently! don't you see that in this way you will break everything? 6. Alas! I am ruined; I do not know what to do. 7. Take care! there is a large ditch in the middle of the garden. 8. What good music, and what good artists! Bravo! Encore! 9. Cheer up! one must not lose courage; the devil is not so black as he is painted. 10. Dear me! these boys are enough to drive one mad. 11. Help! fire! the flames are threatening an oil warehouse. 12. Hulloa! good people, give me a shelter for to-night. 13. This is capital! you have broken the looking-glass, and you want me to pay for it. 14. What a noise! it is not possible to sleep. 15. What a nuisance! let us go away.

Formole di Lettere

Mr. N. N., N. N., Esq., *Signor N. N.*
Mrs. N. N., *Signora N. N., Distintissima signora N. N.*
Miss N. N., *Signorina N. N.*
Sir, *Signore*; Dear Sir, *Egregio signore.*
Gentlemen, *Signori.*
My dear friend, *Carissimo amico.*
Dear Mrs. N., *Gentilissima signora* (*N.*).
Dear Miss N., *Gentilissima signorina* (*N.*).
I am, I remain, *Mi creda.*
Yours truly, *Suo devotissimo.*
Yours affectionately, *Suo affezionatissimo.*

Note. The student is advised to use a good English-Italian and Italian-English dictionary, such as that by Melzi, 6s. net, Hirschfeld Bros., Ltd., 13, Furnival Street, E.C.

Italian *concluded*

ESPERANTO

By Harald Clegg

Suffixes

EDZ denotes a married person.

Examples: *Edzo,* husband; *edzino,* wife. *Doktoro,* doctor; *doktoredzino,* doctor's wife. *Poetino,* poetess; *poetinedzo,* poetess' husband.

EJ denotes a place where an action occurs.

Examples: *Dormi,* sleep; *dormejo,* dormitory. *Kuiri,* cook; *kuirejo,* kitchen. *Preĝi,* pray; *preĝejo,* church.

This suffix is sometimes applied to noun-roots, in which case it indicates place of origin. Thus, *orejo* would be "gold-field" and *fruktarbejo* "orchard."

EM denotes propensity or disposition.

Examples: *Kredi,* believe; *kredema,* credulous. *Labori,* work; *laborema,* laborious. *Ŝpari,* spare; *ŝparema,* frugal.

ING denotes a holder; that into which a *single* object is appropriately placed.

Examples: *Glavo,* sword; *glavingo,* scabbard. *Cigaredo,* cigarette; *cigaredingo,* cigarette-holder. *Violono,* violin; *violoningo,* violin-case.

UJ denotes that which bears or contains.

Examples: *Mono*, money; *monujo*, purse. *Anglo*, Englishman; *Anglujo*, England. *Piro*, pear; *pirujo*, pear-tree.

In naming a country the word *lando* is very often substituted for this suffix.

Examples: *Belgo*, a Belgian; *Belgolando*, Belgium. *Ruso*, a Russian; *Ruslando*, Russia.

And in place of UJ, when trees are indicated, the word *arbo* is very often used.

Examples: *Pomo*, apple; *pomarbo*, apple-tree. *Ĉerizo*, cherry; *ĉerizarbo*, cherry-tree.

Subordinate Clauses

The tense of a simple or compound Esperanto verb in a subordinate clause must always adhere logically to the idea to be rendered, and must never, as often occurs in English, suffer itself to be influenced by a verb in the principal sentence. In English we should say: "I asked him whether he *had* a son," whereas the question asked was whether he *has* a son, this being the original terse of the verb used by the speaker. In Esperanto sentences of this kind the tense of the subordinate verb must remain that which it was when first spoken. Thus, the above sentence would be translated:

"*Mi demandis al li, ĉu li havas filon.*"

A few further examples will help to explain this principle.

My brother said that he would consent, *Mia frato diris ke li konsentos.* The prince asked who she was, *La princo demandis kiu ŝi estas.* My father asked me when I was going to visit him, *Mia patro demandis al mi kiam mi vizitos lin.* She told me that she had sold the house, *Ŝi diris al mi ke ŝi estas vendinta la domon.*

In simple sentences, and principal sentences of complex sentences, too, the student must be careful to guard himself against misuse in English.

Examples: When I am dead you will be sorry, *Kiam mi estos mortinta, vi estos malfeliĉa*; To-morrow is Sunday, *Morgaŭ estos Dimanĉo*; If you loved me I would love you, *Se vi amus min, mi amus vin.*

Vocabulary

afrank', frank or prepay a letter
balanc', sway, swing
balbut', stammer, stutter
dediĉ', dedicate
eks', ex, late
fabel', story, tale
font', source
funebr', funereal
garanti', guarantee
gros', gooseberry
haven', port, harbour
kav', cave, hollow
kel', cellar
kruĉ', jug, pitcher
legom', vegetable
magi', magic
mien', mien, air
milit', war
mov', move (v.t.)
nuks', nut
ofer', sacrifice, offer
ofic', office (duty)
pilk', play-ball
pipr', pepper
prun', plum
pugn', fist
rad', wheel
rem', row (v.)
riproĉ', reproach
sal', salt
serur', lock (subst.)
simil', like, similar
solv', solve
staci', station (railway)
sup', soup
surtut', overcoat
ŝarĝ', load, burden
ŝink', ham
ŝtup', step, stair
ŝvel', swell (v.i.)
tajlor', tailor
taŭg', be fit for
tim', fear
traf', reach, fall in with
trakt', treat of
tren', drag, trail
turn', turn (v.a.)
tuŝ', touch (v.t.)
vast', wide, vast
vek', wake, arouse (v.t.)

Exercise XIX.

Note. The participles are to be used where possible.

He unexpectedly arrived in London last night. In the middle of my garden there grow pear-trees, plum-trees, and gooseberry bushes. Besides those you find all kinds of vegetables. The servant has just laid the covers on the table, but where are the soup-tureen, the salt-cellar, the pepper-box, and the bell? Having been aroused from sleep the tailor opened his (the) eyes and saw the locksmith standing by him. Being naturally very timorous, he stammers somewhat whenever (any) one approaches him. Running rapidly to the station, he just caught the train as it started. The letters were sent postage paid. What a strange swelling there is on your face! This work has been dedicated to my most loved friend. Here are the purse and the jewel-case which I found on the staircase near my office. Many thanks! This cigar-holder strongly resembles mine. In crossing the street the child suddenly fell under the wheels of a carriage. Having been loaded by the stevedores the ship went out of the harbour. The tailor guaranteed that this overcoat was made (out) of the best cloth. In rowing I broke one of the oars. The story of which he was treating is not altogether true. Turning my eyes to the wide sea, I saw the ship slowly moving away until it disappeared. Happily the terrible war between Russia and Japan is now over, but we shall always think of those dead warriors who needlessly offered their lives for their countries.

Key to Exercise XVII.

1. Servant (female), brood of chickens, physician, robber-chief, spinner, temptation, carpenter, butcher, service, nurse (female), duckling, explorer, shepherd, lady-artist, puppy, filly, sculptor, lady-doctor, preaching. The band of robbers were condemned by the judge. A writer (*verkisto*) writes books, and a writer (*skribisto*) simply transcribes papers. They heard the fusillade and the flying bullets. The clerk has confessed that he took the ring and now he is about to be tried (judged) by the judge. When the (female) spinner was ill, the physician visited her, but after some time she died. The iron was forged by the smith.

2. Tiu ĉi estas la rimedo, kiu estas rekomendata de la maristo. La pordo estis alriglita kontraŭ la rabisto. La suspektato estas denuncita de la komizo, kaj li certe estos severe punata. Tiuj ĉi versoj estas elĉerpitaj de la tradukisto, el la verkoj de la plej bonaj verkistoj. Iuj staris sur seĝoj kaj benkoj por pli bone vidi, sed la parolisto ne povis esti aŭdata. Ne estas eble vidi flugantan kuglon. Li estis sonĝanta pri sia malproksima hejmo, kiun eble li neniam vidos plu. Neniu havas la rajton juĝi. Memoru, ke kiu juĝas, tiu estos juĝata. Nun estas nokto, kaj ni povas vidi la brilantajn stelojn super la saŭmanta maro. Amikoj, malofte vidataj, estas amikoj forgesitaj.

Key to Exercise XVIII.

Mi pafis sagon en la aeron, sed perdinte ĝin, mi konkludas ke mi ne estas spertulo. Tiu ĉi ekzercaro, presite per linotipa maŝino, estas nun preta. Pentrante tiun pentraĵon, kaj desegnante ĉi-tiun desegnaĵon, li altiris multe da atento. Vi estas parolinta sensencaĵon. Admirinte la belecon de la meblaro kaj ornamaĵoj, ili prezentis arĝentan moneron al la pordisto. Ŝtalo estas fleksebla, sed fero ne estas fleksebla. Ĉiuj elmigrantoj malŝparis sian monon, kaj alveninte en kompatinda stato, ili ekscitite plendis

pri sia malfeliĉo. Tiu kantanto estas nek aŭdinda, nek vidinda. La skribinto de tiu ĉi letero estas la unua atestanto. Fininte sian manĝadon, li sonoris. Jen estas la rostita bovaĵo. Ĉu vi preferas bovidaĵon, ŝafaĵon aŭ ŝafidaĵon, sinjoro? Tia spriteco nenion signifas. Forprenu ĉi-tiun acidaĵon. Kiam la masonisto estis mortonta, liaj heredontoj venis por ricevi lian benon, kaj dividi lian riĉaĵon. Ilia rapideco poste pikis al ili la konsciencon. Estas pli bone morti malriĉa, ol neamata. La propono estis zorge preparita kaj poste prezentata al la societanaro. Vi estus multe embarasata, se vi scius kiel malprudenta li estas. La arbo estas fendita de la arbaristo per hakilo. Mi povas konscience atesti tion.

Continued

GREEK

By G. K. Hibbert, M.A.

ACCIDENCE. VERBS—continued

Regular Verbs in -μι. Hitherto, with the exception of the two verbs εἰμί, be, and εἶμι, go, we have given the conjugation only of verbs in -ω. We now come to the second class, verbs in -μι. These are distinguished in their inflection from the verbs in -ω almost exclusively in the tenses formed from the present and second (or strong) aorist stems. In the other tenses they agree with verbs in -ω. The following is the conjugation of the present, imperfect and second aorist tenses of the four typical verbs ἵστημι, set; τίθημι, put; δίδωμι, give; δείκνυμι, show:

Active Voice

Present Indicative

ἵστημι	τίθημι	δίδωμι	δείκνυμι
ἵστης	τίθης	δίδως	δείκνυς
ἵστησι	τίθησι	δίδωσι	δείκνυσι
ἵστατον	τίθετον	δίδοτον	δείκνυτον
ἵστατον	τίθετον	δίδοτον	δείκνυτον
ἵσταμεν	τίθεμεν	δίδομεν	δείκνυμεν
ἵστατε	τίθετε	δίδοτε	δείκνυτε
ἱστᾶσι	τιθέασι	διδόασι	δεικνύασι

Imperfect Indicative

ἵστην	ἐτίθην	ἐδίδουν	ἐδείκνυν
ἵστης	ἐτίθεις	ἐδίδους	ἐδείκνυς
ἵστη	ἐτίθει	ἐδίδου	ἐδείκνυ
ἵστατον	ἐτίθετον	ἐδίδοτον	ἐδείκνυτον
ἱστάτην	ἐτιθέτην	ἐδιδότην	ἐδεικνύτην
ἵσταμεν	ἐτίθεμεν	ἐδίδομεν	ἐδείκνυμεν
ἵστατε	ἐτίθετε	ἐδίδοτε	ἐδείκνυτε
ἵστασαν	ἐτίθεσαν	ἐδίδοσαν	ἐδείκνυσαν

Second Aorist Indicative

ἔστην	[ἔθην]	[ἔδων]	None
ἔστης	[ἔθης]	[ἔδως]	
ἔστη	[ἔθη]	[ἔδω]	
ἔστητον	ἔθετον	ἔδοτον	
ἐστήτην	ἐθέτην	ἐδότην	
ἔστημεν	ἔθεμεν	ἔδομεν	
ἔστητε	ἔθετε	ἔδοτε	
ἔστησαν	ἔθεσαν	ἔδοσαν	

NOTE. ἔστην is intransitive, I stood, not I set. The first aorist ἔστησα has the transitive sense, *I set, I made to stand.* The forms in square brackets, ἔθην, ἔδων, etc., are never used: for the singular forms of the second aorist the forms of the first aorist are borrowed—ἔθηκα, ἔθηκας, ἔθηκε, and ἔδωκα, ἔδωκας, ἔδωκε.

Present Subjunctive

ἱστῶ	τιθῶ	διδῶ	δεικνύω
ἱστῇς	τιθῇς	διδῷς	δεικνύῃς
ἱστῇ	τιθῇ	διδῷ	δεικνύῃ
ἱστῆτον	τιθῆτον	διδῶτον	δεικνύητον
ἱστῆτον	τιθῆτον	διδῶτον	δεικνύητον
ἱστῶμεν	τιθῶμεν	διδῶμεν	δεικνύωμεν
ἱστῆτε	τιθῆτε	διδῶτε	δεικνύητε
ἱστῶσι	τιθῶσι	διδῶσι	δεικνύωσι

Second Aorist Subjunctive

	θῶ	δῶ	None
στῇς	θῇς	δῷς	
etc.	etc.	etc.	

Present Optative

ἱσταίην	τιθείην	διδοίην	δεικνύοιμι
ἱσταίης	τιθείης	διδοίης	δεικνύοις
ἱσταίη	τιθείη	διδοίη	δεικνύοι
ἱσταίητον	τιθείητον	διδοίητον	etc.,
or ἱσταῖτον	or τιθεῖτον	or διδοῖτον	like verbs
ἱσταιήτην	τιθειήτην	διδοιήτην	in -ω
or ἱσταίτην	or τιθείτην	or διδοίτην	
ἱσταίημεν	τιθείημεν	διδοίημεν	
or ἱσταῖμεν	or τιθεῖμεν	or διδοῖμεν	
ἱσταίητε	τιθείητε	διδοίητε	
or ἱσταῖτε	or τιθεῖτε	or διδοῖτε	
ἱσταίησαν	τιθείησαν	διδοίησαν	
or ἱσταῖεν	or τιθεῖεν	or διδοῖεν	

Second Aorist Optative

σταίην	θείην	δοίην	None
σταίης	θείης	δοίης	
etc.	etc.	etc.	

Present Imperative

ἵστη	τίθει	δίδου	δείκνυ
ἱστάτω	τιθέτω	διδότω	δεικνύτω
etc.	etc.	etc.	et

Second Aorist Imperative

στῆθι	θές	δός	None
στήτω	θέτω	δότω	
στῆτον	θέτον	δότον	
στήτων	θέτων	δότων	
στῆτε	θέτε	δότε	
στήτωσαν	θέτωσαν	δότωσαν	
or στάντων	or θέντων	or δόντων	

Present Infinitive

ἱστάναι	τιθέναι	διδόναι	δεικνύναι

Second Aorist Infinitive

στῆναι	θεῖναι	δοῦναι	—

Present Participle

ἱστάς	τιθείς	διδούς	δεικνύς

Second Aorist Participle

στάς	θείς	δούς	—

NOTE. ἱστάς is declined like λύσας, and τιθείς like λυθείς. διδούς is declined like λύων, except in nominative and vocative singular :

Nom., Voc.	διδούς	διδοῦσα	διδόν
Gen.	διδόντος	διδούσης	διδόντος
	etc.	etc.	etc.

δεικνύς is thus declined :

Nom., Voc.	δεικνύς	δεικνῦσα	δεικνύν
Acc.	δεικνύντα	δεικνῦσαν	δεικνύν
Gen.	δεικνύντος	δεικνύσης	δεικνύντος
	etc.	etc.	etc.

PASSIVE AND MIDDLE VOICES

Present Indicative

ἵσταμαι	τίθεμαι	δίδομαι	δείκνυμαι
ἵστασαι	τίθεσαι	δίδοσαι	δείκνυσαι
ἵσταται	τίθεται	δίδοται	δείκνυται
ἵστασθον	τίθεσθον	δίδοσθον	δείκνυσθον
ἵστασθον	τίθεσθον	δίδοσθον	δείκνυσθον
ἱστάμεθα	τιθέμεθα	διδόμεθα	δεικνύμεθα
ἵστασθε	τίθεσθε	δίδοσθε	δείκνυσθε
ἵστανται	τίθενται	δίδονται	δείκνυνται

Imperfect Indicative

ἱστάμην	ἐτιθέμην	ἐδιδόμην	ἐδεικνύμην
ἵστασο	ἐτίθεσο	ἐδίδοσο	ἐδείκνυσο
ἵστατο	ἐτίθετο	ἐδίδοτο	ἐδείκνυτο
etc.	etc.	etc.	etc.

Second Aorist Indicative (Middle only)

None	ἐθέμην	ἐδόμην	None
	ἔθου	ἔδου	
	ἔθετο	ἔδοτο	
	etc.	etc.	

Present Subjunctive

ἱστῶμαι	τιθῶμαι	διδῶμαι	δεικνύωμαι
ἱστῇ	τιθῇ	διδῷ	δεικνύῃ
ἱστῆται	τιθῆται	διδῶται	δεικνύηται
etc.	etc.	etc.	etc.

Second Aorist Subjunctive (Middle only)

None	θῶμαι	δῶμαι	None
	θῇ	δῷ	
	θῆται	δῶται	
	etc.	etc.	

Present Optative

ἱσταίμην	τιθείμην	διδοίμην	δεικνυοίμην
ἱσταῖο	τιθεῖο	διδοῖο	δεικνύοιο
ἱσταῖτο	τιθεῖτο	διδοῖτο	δεικνύοιτο
etc.	etc.	etc.	etc.

Second Aorist Optative (Middle only)

None	θείμην	δοίμην	None
	θεῖο	δοῖο	
	θεῖτο	δοῖτο	
	etc.	etc.	

Present Imperative

ἵστασο	τίθεσο	δίδοσο	δείκνυσο
or ἵστω	or τίθου	or δίδου	
ἱστάσθω	τιθέσθω	διδόσθω	δεικνύσθω
etc.	etc.	etc.	etc.

Second Aorist Imperative (Middle only)

None	θοῦ	δοῦ	None
	θέσθω	δόσθω	
	etc.	etc.	

Present Infinitive

ἵστασθαι	τίθεσθαι	δίδοσθαι	δείκνυσθαι

Second Aorist Infinitive (Middle only)

None	θέσθαι	δόσθαι	None

Present Participle

ἱστάμενος	τιθέμενος	διδόμενος	δεικνύμενος

Second Aorist Participle (Middle only)

None	θέμενος	δόμενος	None

The other tenses of these verbs are conjugated like verbs in -ω. They are :

Future Indic.	στήσω	θήσω	δώσω	δείξω
First Aor. Indic.	ἔστησα	ἔθηκα	ἔδωκα	ἔδειξα
Perfect	ἕστηκα	τέθεικα	δέδωκα	δέδειχα

and Passive and Middle accordingly.

ἵστημι has also a second perfect form : infinitive ἑστάναι, participle ἑστώς. This is used only in dual and plural in the indicative : dual ἕστατον, ἕστατον ; plural ἕσταμεν, ἕστατε, ἑστᾶσι.

ἵημι, send, is conjugated like τίθημι, but the third plural present indicative is ἱᾶσι. It has future ἥσω, aorist ἧκα, perfect εἷκα, perfect passive εἷμαι, aorist passive εἵθην.

φημί, say, is conjugated almost like ἵστημι. It has imperfect ἔφην, and future φήσω. The second singular present indicative is φῄς—φημί, φῄς, φησί ; φατόν, φατόν ; φαμέν, φατέ, φασί.

SYNTAX. The Genitive Case

The Greek genitive is a "mixed case," standing both for the genitive proper and for the ablative. In Sanscrit there were eight cases—nominative, vocative, accusative, genitive, dative, ablative, locative, and instrumental. Latin has lost the last two as separate cases, and uses the ablative for both. Greek has lost the ablative as well, and makes the genitive include the old ablative, and the dative include the locative and instrumental.

A. **The Genitive Proper.** The genitive proper most often qualifies a noun, less often an adjective, adverb, or verb. It denotes 1 Origin. 2. Possession. 3. Object. 4. Quality. 5. Material. 6. Relation of whole and part.

1. ORIGIN, generally of paternity, as Διὸς Ἄρτεμις, Artemis (daughter) of Zeus. Under this head may be classed the "genitive of cause" and the "genitive of exclamation." The Genitive of Cause is common after verbs expressing emotions, as *wonder, pity, envy, revenge*, etc.—as : ζηλῶ σε τοῦ νοῦ, I envy you for your mind. It is also frequent in legal language after verbs of *accusing, acquitting, condemning, convicting*, etc.—as : διώκει με φόνου, He prosecutes me for murder ; φεύγειν φόνου, to be charged with murder. The Genitive of Exclamation gives the cause of the astonishment or grief —as : ὤμοι ἐμῆς ἄτης, Alas, for my infatuation !

2. POSSESSION, the chief noun being often omitted—as : τὰ τῶν Ἑλλήνων, the possessions of the Greeks. It may be used predicatively after a verb—as : ἐστιν ἀνδρὸς σοφοῦ κοσμίως βιοῦν, It is the part of a wise man to live discreetly. With this may be classed the "Subjective Genitive," denoting the subject of an action or feeling—as : ἡ τοῦ δήμου εὔνοια, the goodwill felt by the people. This is sharply contrasted with the next use.

3. OBJECT, often called the "Objective Genitive," denoting the direction or object of the action, or feeling. After a noun—as : ἕρκος πολέμου, a protection against war ; πεῖρα ἐχθρῶν, an attack on one's enemies ; τὸ Μεγαρέων ψήφισμα,

the decree concerning the Megareans (*not* proposed by them); ἡσυχία ἐχθρῶν, peace from foes. After an adverb—as: λάθρῃ Λαομέδοντος, unknown to Laomedon. After an adjective or participle—as: ἐπίστροφος ἀνθρώπων, conversant with men; τόξων εὖ εἰδώς, well skilled in the bow. After a verb, to express (*a*) direction of physical effort—*e.g.*, after verbs like *begin, rule, try, touch, aim at, desire, guide, reach, fail of*—as: ἔτυχε (τυγχάνω) οἴκτου, He gained pity; ἅψασθαι (ἅπτομαι) χειρός, to cling to someone's hand; οὐ πολέμου ἄρχομεν, We do not begin war. (*b*) direction of mental effort, after verbs like *hear, know of, speak of, remember, remind, forget, perceive*—as: φωνῆς ἀκούω, I hear a voice; ἀλκῆς μνήσασθαι, to remember one's strength.

4. Quality or Description—as: ὄμμα τόλμης πικρᾶς, an eye of cruel daring; τινὲς τῆς αὐτῆς γνώμης, some men of the same opinion. With this we may class the "Genitive of Price"—as: πέντε μνῶν τιμᾶται, He is valued at five minae; ἄξιός ἐστι θανάτου, He is worthy of death; ποσοῦ διδάσκει; For what price does he teach? Also the "Genitive of Definition"—as: ἕρκος ὀδόντων, a fence formed by the teeth.

5. Material—as: εὐνὴ ἐσθῆτος μαλακῆς, a bed of soft clothes; αἱ δὲ βόες χρυσοῖο (Homeric genitive form) τετεύχατο κασσιτέρου τε, The cows were wrought in gold and tin.

6. Partitive Genitive—*i.e.*, the genitive of a noun which in the nominative denotes a divisible whole—as: δέπας οἴνου, a measure of wine; θεῶν Διί, to Zeus among the gods; πολὺ τῆς γῆς, much of the land. It is often used after an adverb—as: ἄλλοθι γαίης, in another land (*lit.* elsewhere of land). But the most important use is after a verb: (*a*) Predicatively after "to be"—as: ἤθελε τῶν μενόντων εἶναι, He wished to be one of those who remained. (*b*) The genitive denoting that of which part, not the whole, is given or taken—as: τῆς ἑαυτοῦ γῆς ἔδωκε, He gave some of his own land. Similarly after verbs like *fill, lack, enjoy, taste, smell, spare, share*, etc.—as: κρομμύων ὀσφραίνομαι, I smell onions; μέλιτος γεύεσθαι, to taste honey; μετέχω τῆς λείας, I share the spoil. Sometimes after a negative adjective—as: ἀδωρότατος χρημάτων, taking (of) no bribes. (*c*) A genitive of *place* or *time* may be used in loose dependence on a verb to denote the limits within which the action is confined, as the accusative is used to denote the extent of the action. *Place:* ἔρχονται πεδίοιο, They go through the plain; ποῦ γῆς; Where on earth? In prose this use is found in a genitive neuter of an adjective used adverbially with a verb of "wanting"—as: δέω πολλοῦ, I fail by much; ἐλαχίστου ἐδέησε διαφθεῖραι, It came within an inch of destroying (*lit.* it lacked very little to destroy). It may even be used as a plain adverb, as μικροῦ, nearly. *Time:* νυκτός, by night; δραχμὴν τῆς ἡμέρας, a drachma a day.

B. **The Ablative Genitive.** This denotes the "terminus a quo"—*i.e*, motion or separation from a person, thing, or place. It is used (*a*) after a verb, to denote motion from—as: Ὀλύμποιο (Homeric genitive) κατήλθομεν, We came down from Olympus; or to denote "hearing from" a person, after ἀκούω, κλύω, κ.τ.λ. It may also denote separation in general—as: Τρῶας ἄμυνε νεῶν, He kept the Trojans off from the ships. (*b*) After a comparative—as: μείζων ἐκείνου, greater than he; the idea being "the greater, starting from him, or as viewed from him." This genitive is used after verbs, adjectives, or adverbs implying comparison—as: ἡσσᾶσθαί τινος, to be weaker than someone, to be beaten by him; ἕτεροι τούτων, others than these; ὕστεροι τῆς μάχης, too late for the battle; κάλλιστον τῶν προτέρων, fairest of those before (*i.e.*, fairer than all predecessors); μεγίστην τῶν πρὸ αὐτῆς, greater than any before it.

C. **The Genitive Absolute.** A noun and a participle, not connected with the main construction of the sentence, may stand by themselves in the genitive. This is called the genitive absolute (corresponding to the ablative absolute in Latin)—*e.g.*, δύοντος τοῦ ἡλίου ἀφίκετο, As the sun was setting, he arrived; ἐμοῦ καθεύδοντος ταῦτα ἐγένετο, This happened while I was asleep; τούτων οὐκ ἀφικομένων ἀπήλθομεν, As they had not come, we departed; ταῦτα ἐπράχθη Κόνωνος στρατηγοῦντος, This was done when Conon was general; μηδενὸς ἐπαρκοῦντος ἀπόλωλα, If no one aids, I am ruined. The participle sometimes stands alone, the noun being understood—as: οὕτω δ' ἐχόντων, εἰκός ἐστιν, κ.τ.λ., And this being so (understand πραγμάτων, *lit.* things being so) it is likely, etc. This is the regular construction, the accusative absolute being confined to certain impersonal verbs.

Key to Translation ("The First Glimpse of the Sea").

Thence they marched through the Chalybes and came to a great city which was called Gymnias. From this city the ruler of the country sends a guide for the Greeks, and he coming said that he would bring them to a spot whence they could see the sea. So he led them, and on the fifth day they reach the mountain. When the vanguard were on (the summit of) the mountain and caught sight of the sea, there arose a great shout. Xenophon and the rearguard, hearing it, thought that an enemy was attacking those in front. But when the shouting became more, and those who kept coming up ran at full speed to those who kept on shouting, it seemed to Xenophon to be something more serious (*lit.* greater); so mounting his horse and taking the cavalry, he went to the rescue. Soon, however, they hear the soldiers shouting, "The sea! The sea!" and encouraging one another. Then they all ran; and when they got to the top, there they embraced one another, generals and captains alike, weeping. Immediately the soldiers carry stones and make a great heap. After this the Greeks dismiss the guide, giving him gifts: a horse, a silver vessel, a Persian dress, and money; and he, having shown them a village where they ought to encamp, and the way which they should go, went away in the night.

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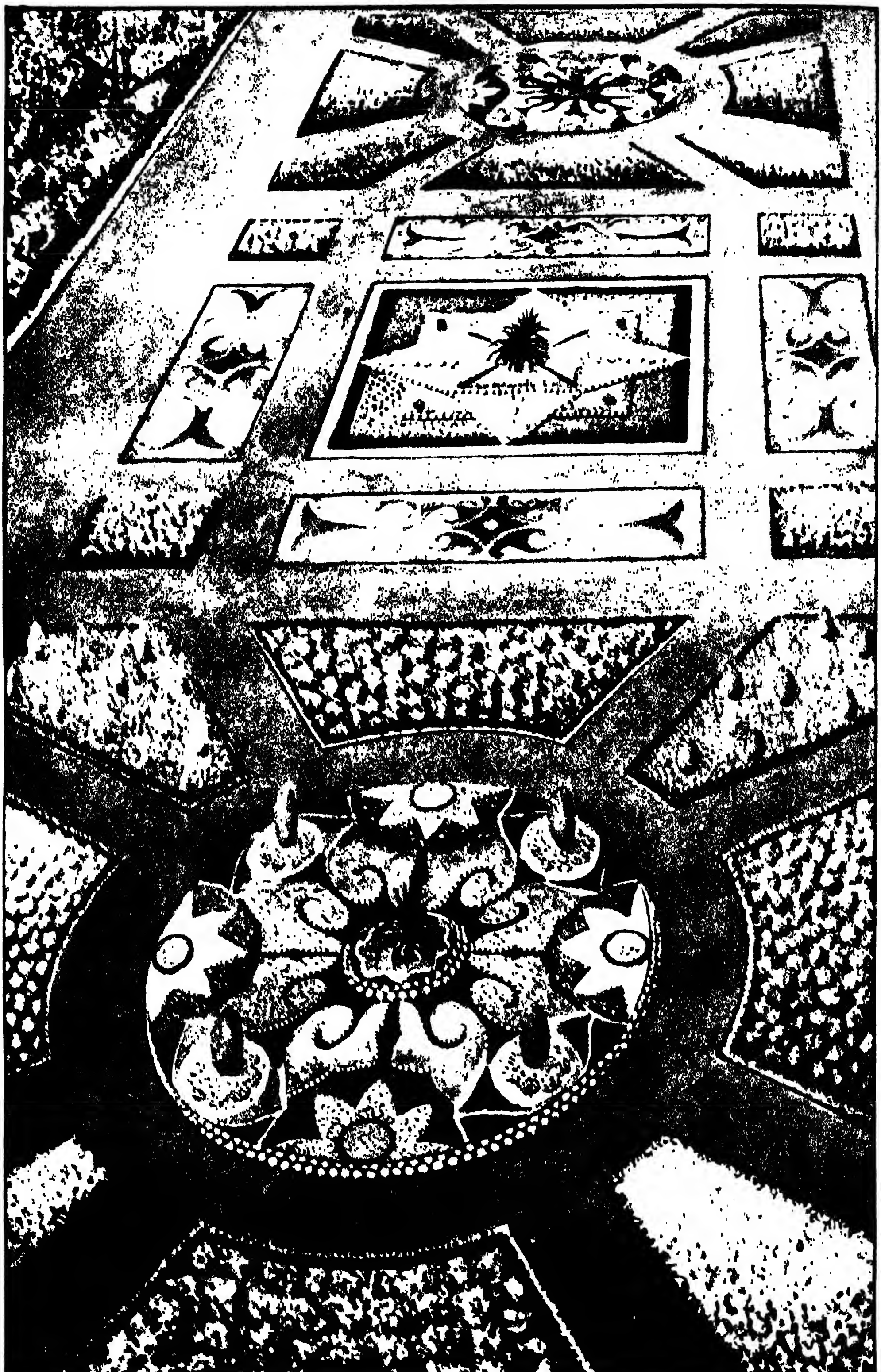


A CARPET OF FLOWERS

TALL PLANTS & GLASSHOUSES

The Tall-growing Flowers. The Management of Glasshouses. Greenhouse and Hothouse Plants and Ferns for Home and Market. Orchids

By H. H. HAVART

WHEN first laying out a garden, or altering the appearance of an existing one, the proper use of the taller plants is a matter which requires very careful consideration. In a small garden the employment of many tall plants is a mistake, for not only do they overshadow the humbler plants growing at their feet, but their general effect is to make the garden appear smaller than it really is. In fact, the only positions in which tall-growing flowers can be employed with advantage in small gardens is in the borders against a wall or fence. Even then, if there are many of them, they give the place a somewhat military appearance, with their spiky heads standing in rows like bayonets.

In large gardens the tall flowers can be used in profusion almost everywhere, to break up the monotony which would otherwise be produced by the dead level of height of about 2 ft., which is attained by so many of our fairest garden flowers. They may be used in clumps in borders, or in the centres of large beds, or they look particularly charming in beds by themselves set in the middle of an expanse of turf, so that they can be admired at a little distance.

Hollyhock and Larkspur. The hollyhock is one of the most useful of the tall-growing flowers, and, although it is sometimes called old-fashioned, it is without a rival for effectiveness in poor soils. It is no uncommon thing to find these plants self-sown in gardens, but such varieties are best relegated to the wild garden. The choicer sorts, however, deserve to be cultivated everywhere. There are two ways of growing hollyhocks. One is to sow seed in autumn in a cold frame, protecting it during the winter, and putting the little plants out in spring; and the other is to sow in February in heat, and plant out in spring or early summer with the bedding stuff. The former method usually gives sturdier plants. The average height of the hollyhock is about 6 ft. or 7 ft., though there are many instances on record where they have attained an altitude of nearly 20 ft. Nurserymen keep a good many sorts, varying in colour from white to a very dark crimson, which is almost black, and including yellow. There are also double-flowered sorts, all of which are worth growing where there is sufficient space.

The tall-growing larkspur (Delphinium) must not be confounded with the ordinary larkspur of the garden. Though both belong to the same family, the tall larkspur is a perennial [29], while the ordinary larkspur is an annual, and must be sown afresh every season. The perennial larkspurs can be raised from seed, either by sowing in heat in the early spring, and planting out the seedlings where they are to flower, or by sowing in the open ground in the summer, in which event good strong plants will be obtained to bloom the following year. Though the larkspurs do best in loam, they may be made to thrive in a light sandy soil provided it is well manured and freely watered. The many new hybrids embrace all sorts of colours from pale yellow to purple and red, but the rich blue sorts are, perhaps, of the greatest value for general garden purposes. Their average height is about 5 ft., though some of the newer hybrids are much taller. As these larkspurs increase rapidly, they should be dug up and the roots divided every four or five years. When once they have started flowering, they can be made to continue to do so for several months by cutting off a flower spike as soon as it has done blooming, when another one will immediately begin to make its appearance from the root of the plant.

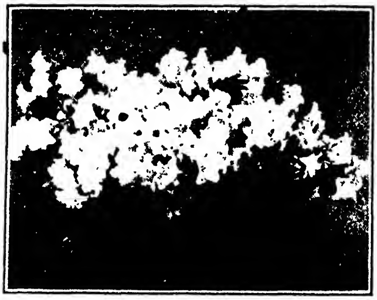
The Garden Foxglove. To the novice who knows the foxglove only as a tall, pale purple plant of our lanes and hedgerows, and is apt to regard it as almost a weed, the idea of growing it in a garden may seem peculiar. As is the case with many other flowers, however, it has been taken in hand by nurserymen, who have raised many new and valuable sorts. Foxgloves require a good deal of space, however, and for that reason must be introduced into a small garden with care, as they soon develop a habit of sowing themselves. Hence, under such circumstances, they are best used as specimen plants in large beds. The method of culture is similar to that already given for the delphinium, and the white variety is the most imposing, often attaining a height of 6 ft. Canariensis, with flowers of a brown colour, and Grandiflora, having yellow blooms, are two interesting sorts if variety is desired, while there are several sorts with spotted flowers known as gloxinia-flowered foxgloves, which are interesting.

As with the larkspur, it is the perennial lupin which is the tall-growing variety of lupins. The culture of lupins is simplicity itself, as the seed simply needs to be sown in any garden soil in spring, and the plants thinned out when they are a few inches in height. The thinning should be drastic, for the lupin is of bushy habit as growth proceeds. Though, strictly speaking, perennials, lupins frequently fail after three or four years, but they are so easily grown from seed that this is not a matter of great importance. The best sort, especially in a poor soil or a rocky corner, is the tree lupin (*Lupinus arboreus*), a stout, bushy plant, with stiff spikes of yellow flowers, reaching to a height of 4 ft. or more. *Lupinus polyphyllus* is an even taller sort, with purple-blue flowers, and of this species there is a white variety—Albus. All the tree lupins are excellent plants to employ in large places where the formal garden melts away into the woodland, and the soil is probably not so rich, or constantly worked, as it is nearer to the house.

Flame Flower or Torch Lily. This is a valuable plant of many names. It boasts two Latin names—*Kniphofia* and also *Tritoma*; while it is also known in different parts of the country as the torch lily, and sometimes as the red-hot-poker plant. It is a hardy perennial, cultivated in the same way as the delphinium, and at its best in a deep rich soil, though it will thrive in practically every garden. When it is desired to increase the plants, they should be taken up and the roots divided, either in spring or autumn. The most popular variety of the flame flower is *Kniphofia aloides*—attaining a height of 6 ft. or more, and

having long flowering spikes of particularly brilliant scarlet flowers, shading to orange. It is the peculiar brilliance of the flower's spikes which has earned for it the name of red-hot-poker plant. An excellent plan to adopt with it, though it is rarely put into practice, is to mass it near the edge of a lake, in company with bamboos and pampas grass, where it gives a charming effect in the autumn.

The Despised Sunflower. Although many people pretend to despise the sunflower (Helianthus) [25], to do so practically amounts to a profession of ignorance regarding the plant. Certainly the ordinary annual sunflower, frequently met with in suburban cottage gardens, is not a plant which it is desirable to employ extensively, as it takes a lot of nourishment out of the soil. Several of the varieties of perennial sunflowers, however, are among the most valuable of the taller flowers of the garden, as the brown-centred yellow blossoms give a blaze of colour equalled by few other flowers of this class. The flowers are not particularly large, being in most of the varieties about 3 in. in diameter, but they are borne in great profusion. Their best use is, perhaps, singly, in beds, as they are of bushy habit, and, consequently, take up a good deal of room, though where there is a large shrubbery they may be massed with good effect. They are raised from seed in the same way as delphiniums, and may be sown in the open air early in April, where they are to flower. It is well to dig them up and part them every three years, as they increase very rapidly, and are apt to get out of hand if left undisturbed for a period longer than this. The best sorts are: Gigantous (10 ft.); Orgyalis (8 ft.); Decapetalus (6 ft.).



23. DUTCH PEARL AZALEA
For the greenhouse

Other Tall Flowers. Though most of the hibiscuses are generally considered to be greenhouse flowers, there are several of them suitable for open-air culture in favoured spots, particularly in the gardens in the south and west of England, and where deep and rich soil is available. In such circumstances, the best way to grow them is to treat them as half-hardy annuals, sowing the seed under heat in February, and planting out in the late spring. The variety most likely to succeed is *Hibiscus manihot*, which sometimes reaches a height of 5 ft. or more, and has yellow flowers, with a dark crimson centre. Another hardy hibiscus, which is often classed as a shrub, is Syriacus (the Rose of Sharon), reaching to a height of 8 ft. or 9 ft. under favourable circumstances. It makes a good centrepiece for a bed on a lawn, but should be used sparingly. There are hybrids with flowers of all colours from white to crimson.

24. GREENHOUSE HEATH

Humea elegans is a half-hardy biennial plant—that is to say, seed must be sown one year for it to bloom the next, after which it dies. The seed should be sown after the middle of the summer in pots of rich soil, and given an occasional dose of liquid manure during the winter, as only by feeding them liberally can the best results be obtained. About a year after sowing they will be ready to plant out, and they may be used either at the back of the border, as a specimen on the lawn, or as centrepieces to a bed. They range from 5 ft. to 8 ft. in height, according to the soil and position in which they are grown, and have long feathery-like spikes of red-brown flowers.

In addition to the foregoing, many beautiful flowering shrubs may, with advantage, be introduced into bed and borders, instead of confining them to the shrubbery. It is necessary to make such introductions with care, as if overdone the tenderer plants will soon be starved to death. Shrubs which are suitable for such a purpose include the hydrangea, pæony, *Daphne mezereum*, some of the choicer rhododendrons, magnolias, flowering currants, spireas, and the mock orange.

How to Manage a Glasshouse. Glasshouses are roughly divided into three sections—the cool house, the intermediate house, and the hot house. In the cool house, no artificial heat of any sort is employed. The intermediate house, which may, perhaps, be more readily recognised by its popular name of "heated greenhouse," is one in which the winter temperature is always kept at least 15° above freezing point, and the hothouse, or stove, where most of the exotics are grown, should always be held up to a minimum of 10° above this. All houses require the same sort of treatment in their general management.

Hot water is the universal system by which houses are heated, and soft water, if it can be procured, is the best to employ, hard water quickly fouling the pipes. With the ordinary upright boilers, coke is practically as good as coal for stoking purposes, and has, at the same time, the merit of being more economical. It will burn longer, however, and maintain a regular heat better, if it is first slightly damped and mixed with coal dust. This latter is the best method to employ when making up the fires to last all through the night, as, if once the temperature of the house is allowed to fall below the point at which it ought to be maintained, fatal results may follow. Every greenhouse should be furnished with maximum and minimum thermometer, the tube of which contains tiny glass indexes, one of which indicates in the morning the lowest point to which the temperature has fallen during the night, while the other shows the highest point touched.

Although the purpose of greenhouses is avowedly to grow tender plants, it must not be forgotten that the more a greenhouse is ventilated, the healthier will be the condition of its occupants, provided the atmospheric conditions are right. On dull, wet, or foggy days, but little air can be given, but when the

weather is bright and warm, the ventilators can be opened all day long, provided an eye is kept on the thermometer. Cleanliness is an essential feature in the management of a greenhouse. Before any potting is done, the pots should be scrubbed perfectly clean, and this cleanliness should be maintained after they are filled by washing them over outside at intervals of a week or two. The shelves of the greenhouse should be washed down at least once every three weeks, and the glass itself, as well. This operation also affords facility for looking over the plants. Such a house cleaning, if it may be so termed, not only benefits the plants themselves, and improves the appearance of the house, but it also helps to keep away insect pests.

Never use cold water in a hothouse when watering plants. It should always be a few degrees higher in temperature than the atmosphere in the house. The best time of the day to water is about the middle of the day in winter and the evening in the summer-time. In the spring and autumn, watering may be done early in the morning. Greenhouses in very sunny positions will require to be shaded in the summer-time from the glare of the sun in the middle of the day. This shading usually takes the form of a blind which can be pulled down over the roof and let up again when necessary. Five or six hours in the middle of the day is generally long enough for this shading to remain down, provided the sun does not go in, in which case it should be pulled up immediately. In the place of these blinds, or shades, a mixture of whitening and water is sometimes thrown over the sunny side of a house, but this rough and ready method of shading has two drawbacks—it whitens everything with which it comes in contact, and cannot, moreover, be removed instantaneously during a cloudy time.

The Flowers of the Greenhouse. The proper arrangement of the greenhouse is one of the gardener's most difficult duties, especially if the space under glass at his disposal be limited.

Where there are two greenhouses only, it is certainly better to devote the larger one entirely to show, and keep the smaller one for rearing seeds and cuttings—that is, assuming that one is a warm and the other a cool greenhouse. The ideal way is, of course, to have houses of three different temperatures in duplicate, one for show and the other for use, looking at it from the gardener's point of view. So much depends, however, upon the likes and dislikes of an employer that no definite rules upon the subject can be laid down.

For the purposes of this article, the word "greenhouse" is intended to mean the general purpose, or intermediate house, the temperature of which is not allowed to drop below 40 deg. in the winter. Practically all the summer and autumn bedding plants mentioned on page 6492 may be flowered in the greenhouse, and bloom had several weeks earlier than if they are planted out in the open ground. Daffodils, tulips, lilies of the valley, and all the other spring-flowering bulbs may readily be forced on in boxes for cutting or table decoration.

The Most Important Greenhouse Plants. The abutilons are a family of fairly large sized shrubs requiring a good deal of room, and therefore out of place in a small greenhouse. They are raised from seed sown in early spring, or from cuttings of old plants taken at the same time. As soon as the plants are big enough to handle they must be repotted into larger pots, and the process repeated at intervals until the plants are full grown; in this state they often attain a height of 6 ft. The best sorts, especially for commercial purposes, are Boule de Neige (white), Royal Scarlet (red), and Golden Fleece (yellow).

The acacia is better known by its popular name of mimosa, and is best raised from seed sown in spring in the ordinary way, as attempts to propagate it from cuttings are rarely successful. There are several sorts, all very much alike, but the best for general purposes is *Acacia dealbata* where space is of no object. It is this variety which is sold in such huge quantities in the streets of towns and cities. A lot of it comes to London from the South of France, but English grown mimosa usually realises an average price of 4s. per "pad." All the acacias flower in spring time, except Platyptera, which is an autumn-flowering variety.

25. DWARF SUNFLOWER
(Helianthus multiflorus)

Azalea. The azalea in the greenhouse is now usually grown in the form of the small pot plant, so familiar in the florists' windows. Although a hard wooded plant, its culture is very similar to that of the camellia, except that it should be grown in pots instead of tubs. It flowers during the early spring, and should be stood out about June, giving plenty of water so that the wood can ripen properly. In the south and west of England some sorts grow into bushes in the open. *Azalea mollis*, Indica, Fielder's White, and Dutch Pearl [23] are the most useful sorts. Good market plants fetch from 24s. to 30s. per dozen.

Begonias are among the most valuable winter-flowering plants of the greenhouse, while there are in addition some sorts equally desirable on account of their brilliantly marked foliage. They are not at present seen to a great extent in private greenhouses, but they are largely grown for the market. They are best propagated by cuttings taken in the spring, and potted up in tiny "thumb" pots, in loamy soil, with a good layer of silver sand on the top of it. If allowed to have a warm corner in the greenhouse for the first month or two they will make rapid growth, and when the pot is full of roots the plant should be shifted into a 5-in. pot, where it will flower the following winter. The best sorts are Gloire de Lorraine, President Carnot, Winter Cheer, Metallica, and Semperflorens, while of the fine foliage sorts the varieties of Begonia Rex are mostly sought after. Average market price, 10s. per dozen in pots.

Calceolaria and Camellia. The shrubby section of calceolaria used for bedding out has already been dealt with, but the herbaceous varieties are equally important, as they include many choice new hybrids for specimen and exhibition purposes. They must be sown one summer to bloom the next, in very finely powdered loam and sand, moistening the soil first and sprinkling the seed very finely over the surface. The box, or pan, in which the seed is sown must then be covered with a sheet of glass, and put in a moist corner of the house. As soon as the plants are large enough to be handled they must be transferred to "thumb" pots, and afterwards to those of larger size, in which they are to bloom. As herbaceous calceolarias like moist and shade care should be taken to shield them from the direct rays of the sun. Practically every nurseryman of any note has his own choice list of hybrid calceolarias, of all sorts of colours and markings.

By far the best way to grow the camellia is in a tub. Although essentially a greenhouse plant, it can be moved out of doors the summer after it has done flowering, and its home in the greenhouse occupied for a few months by something else. The best time of the year to start camellia culture is in August, when the plants should be repotted, in a mixture of loam with a little peat. In the case of the camellia, repotting does not necessarily mean putting into a larger pot, for it is one of those things which seem to do best without too much root room. The plants should be brought indoors in October, and given an occasional weak dose of liquid manure, and they will flower from the end of November onwards. The well-known white camellia is called Alba Pleno, and is the easiest of all to grow. The best pinks are Lady Hume's Blush and Beauty of Waltham; of the reds, C. M. Hovey and Donckelaari. Although there is a huge demand for market camellias it is not a very paying branch of horticulture, as the prices run low. From 1s. to 1s. 6d. per box of two dozen blooms is the average price.

26. STEPHANOTIS
The sweetest-scented flower of the greenhouse

Cinerarias are pretty decorative plants of many hues and colours, and are best raised fresh from seed every year. This seed may be started in a cool frame in light, sandy soil in the month of May, and the seedlings transferred to "thumb" pots as soon as they are large enough to handle, repotting them once more as required. As soon as the first sign of frost makes its appearance they must be transferred to the greenhouse, but not the hottest part, as they are satisfied with quite a moderate temperature. They will bloom from Christmas until quite late in the spring. There is generally a good demand for them at Covent Garden during the winter months, their chief use apparently being to stand on the dining-tables of hotels, a purpose for which they are well adapted, as they last in bloom a long time.

Hardy Greenhouse Flowers. In the south and west of England, the hydrangea is hardy, but it is generally grown as a greenhouse plant. In its popular form, and the one in which it is always seen on the market, it is a one-stem plant with a big head of bloom. These plants are obtained by taking the stout shoots of old plants and treating them as cuttings, in any ordinary potting soil, when they strike readily and make rapid growth. The natural colour of the flowers is pink, but they may be induced to show blue blossoms by soaking the soil with alum water, or growing them in soil in which there is naturally a good deal of iron. Limited market demand at 10s. to 15s. per dozen.

The heaths [24] are best grown in a mixture of peat and silver sand. They are useful for table decoration in winter, and are not difficult of culture if kept liberally watered and well drained. The most popular sorts for greenhouse culture are Gracilis, Hyemalis, and Ventricosa. There is a constant market demand for them, as, in the hands of an amateur, they usually bloom to die, and, in the winter plants in 5-in. pots may realise anything from 9s. to 20s. per dozen. There are over 500 sorts, mostly differing but slightly.

Primulas, Carnations and Chrysanthemums. The seed of the hybrid Chinese primulas should be sown in June in well sifted soil composed of loam and leaf mould, and treated in the manner described for calceolaria, taknig care to keep them in the dark until the seed germinates. Their final potting should be into a 5-in. pot, and they will bloom from November until spring. The flowers are all shades of white, red, blue, magenta, and pink. A branch of the family much grown is *Primula obconica*, but it should never be handled except in gloves, as it is prone to set up an irritating skin disease.

Hardy flowers cultivated in the greenhouse include the carnation and chrysanthemum Their culture is practically the same as that recommended for out of doors. The variety of carnation for greenhouse culture is known as the tree carnation. It may be had in flower in either autumn, winter, or spring, according to the time the cuttings are taken, hence it is easy to arrange for a succession of bloom. Cut flowers of winter carnations fetch anything from 1s. to 2s. 6d. per dozen. For market purposes, chrysanthemums realise 3s. to 4s. per dozen bunches, of about two dozen blooms each, but the large specimen chrysanthemums are marketed at anything from 2s. to 5s. per dozen blooms.

The Ferns of the Greenhouse. Most of the maidenhair ferns thrive well in greenhouse temperature, especially the popular variety *Adiantum cuneatum*. Large quantities of maidenhair ferns are grown for market purposes, chiefly by division in spring, or from spores, but they need special houses for their culture if they are to be profitable: this particularly applies to the small maidenhair ferns which are frequently to be seen hawked about the streets in "thumb" pots, and for which the market price is about 1s. per dozen.

The peculiarity of the hare's-foot fern (Davallia) is the curious, brown creeping stems which lie on the surface of the soil, and give rise to the popular

name. The ferns are well suited for a small greenhouse rockery, as they are shallow rooting things, and may be well grown in peat and moss. One of the varieties, Mariesi, comes into this country in large quantities from Japan, rolled up in the form of balls, and twisted on wire into the shape of frogs, monkeys, and other curious devices. These are the well-known "Japanese fern balls," and, given gentle heat, and plenty of moisture, soon cover themselves with green shoots. They are useful as novelties, but otherwise are of little horticultural value.

The following ferns are also well adapted for greenhouse culture: *Asplenium bulbiferum, Lastrea patens, Nephrodium molle, Polypodium aureum, Pteris argyraea*, and *P. tremula*. The same methods may be applied to almost every fern that requires the aid of artificial heat to bring it to perfection. A general mixture of loam, leaf mould, and sand should be employed, and the mixture carefully gone over to see that it is not lumpy.

27. LADIES' SLIPPER ORCHID
Cypripedium

Repotting young ferns, or the separation of the roots of old ones, should be done towards the latter end of March, care being taken that at no time are they subjected to the full rays of the sun. Moisture should be given in plenty, but the pots or brackets in which the ferns are grown should be provided with sufficient drainage to allow the water to clear away easily, as stagnant moisture at the roots is fatal to them. The majority of ferns may be propagated from the spores, found on the under side of the leaves. When these cases begin to burst the frond should be cut off and carefully wrapped away in clean paper. In the course of a few days, the remainder of the spore cases will have burst, and a very fine dust will have come out of them. This dust should be carefully spread very thinly on the top of a shallow pan or box, containing plenty of drainage and a mixture of loam, sand, and a little peat. The pan should be gently moistened and covered with a sheet of glass, and, in the course of six weeks or so, if the moistening has been regularly attended to, what appears to be a covering of young green moss will show itself on the surface of the soil. This moss is simply a huge collection of tiny ferns, and may be pricked off as soon as it can be handled into other boxes or small pots to develop.

The Care of the Hothouse. The hothouse, which is also known as the "stove," is used for preserving and growing all the choicest exotics which come to us from the tropics. Though the maintenance of a row of tropical houses is an essential feature of large establishments it is often overdone in gardens of moderate size, for, with the exception of the orchids, the flowers of the "stove" are not of great importance so far as their beauty is concerned.

The remarks on the care of a greenhouse given above apply equally to the hothouse, except so far as temperature is concerned. The hothouse should never be allowed to fall below 60° in the winter, and though much less heat than is usually thought necessary will be required in the summer, the thermometer should never fall below 70° at this period. Most exotics are moisture loving plants, and the use of hot-water pipes has a tendency to dry the atmosphere. Moisture must, therefore, be artificially supplied, either by fitting shallow troughs filled with water over the pipes, or else by liberally syringing the floor and wooden stages with water at frequent intervals.

Popular Inhabitants of the Hothouse. The Amazon lily (Eucharis) is a beautiful white lily like flower, the plants bearing it attaining a height of about 18 in. The flowers are deliciously fragrant, and, as there is always a huge demand for them for bouquets and wreaths, they are well worth growing for market purposes, especially as they can be made to flower practically all the year round. They are grown from bulbs, which should be potted up in a mixture of loam and leaf mould, one bulb to a 5-in. pot. As they will not bear repotting frequently, the nourishment which they would have found in fresh soil must be applied by doses of liquid manure. Under this treatment they will yield two or three crops a year, and the average price of the flowers is about 3s. a dozen.

Though not grown to any large extent in private places, there is an enormous demand for gardenias at blo , both for cheap buttonholes, and also for funeral wreaths. The gardenia is a small bush about 18 in. in height having very deep glossy green leaves, and white flowers with rather a sickly perfume. If potted up in the ordinary mixture of loam and leaf mould with a little red sand, and given plenty of heat and moisture during spring and early summer, they will flower freely through autumn and winter, or they may be had at practically any time by checking the growth. Cuttings stuck into sandy soil in spring root freely, and soon bear flowers, and this is the method generally adopted by market growers. The average price of the cut blooms is 1s. a dozen.

28. CATTLEYA ORCHIDS

Stephanotis [26] is the most widely grown of all the climbing plants in the hothouse. It has white waxy-like flowers of great fragrance, and is best grown in pots plunged into the border, or on a staging, as, if the roots are allowed too much room, the plants run to leaf instead of flower. The ordinary potting mixture suits it admirably, and it is increased from cuttings in the spring.

Ferns in the Hothouse. To avoid repetition, the reader is referred to the ferns of the greenhouse which have been dealt with above for details of culture, these details being equally applicable to the hothouse, the great difference between greenhouse and hothouse ferns being the natural one of temperature. It is more important than ever, however, that in the hothouse the ferns should be well shaded and kept moist—accidental exposure to bright sunshine, especially if the atmosphere happens to be a little dry, will wither them up and kill them

almost immediately. The following ferns are most useful for stove cultivation, and, as they have no English names, it is necessary to set forth their Latin ones in order that the plants may be readily procurable: *Adiantum caudatum*, *A. farleyense*, *Asplenium formosum*, *A. longissimum*, *Blechnum brasiliense*, *Davallia elegans*, *Gymnogramma calomelanos*, *Lomaria boryana*, *Polypodium diversifolium*, *O. pectinatum*, and *Pteris tricolor*.

Orchids. There is no branch of gardening which has been made more bewildering, and more difficult to understand for the young horticulturist, than orchid growing. This is in a great measure due to the fact that new hybrids, the differences in which are indistinguishable even to experts, are being introduced every day. It is appalling to think that at the present time there are over 4,000 varieties of orchids, many boasting Latin names of six words in length, ranging from the Odontoglossum, for which 1,150 guineas was paid in London in March, 1906, down to the *Cœlogyne cristata*, procurable for a shilling or two. A general knowledge of the requirements of the varieties of the great families of orchids is, however, all that the young gardener can reasonably be expected to possess.

When orchids first arrive in this country from abroad they are naturally in a very dry, shrivelled condition, and can have no better treatment than that recommended by Mr. W. H. White, F.R.H.S., in his excellent work, "The Book of Orchids." "The plants should, within a few days after their arrival, be suspended head downwards in an intermediate temperature in a shady part of the house, and be slightly syringed at least once a day. In a very short time the leaves will have assumed their natural colour, and the stems and old root stumps will commence to emit their new succulent roots. Immediately this is observed the plants should be taken down and placed in as small pots as possible, using the crocks for potting, so as to come up almost to the edge of the pot, covering the whole with good living sphagnum moss, and pressing it down moderately firm."

29. PERENNIAL DELPHINIUMS

The Most Important Genera of Orchids. The Calanthes are winter flowering orchids, the different varieties of which will give a succession of bloom for at least three months. They are grown in pots, half filled with drainage, this being covered with a piece of turf, grass downwards, and the pot filled with loam, sphagnum moss, and silver sand. A little water should be given to the bulbs until the foliage begins to make its appearance, but as the plant grows the quantity should be increased until a copious supply is found needful. This quantity should be gradually decreased as the foliage dies down, and the flowers make their appearance. After flowering they should be given rest for a month or two, and the bulbs repotted again in the spring. Some of the Calanthes do not lose their foliage in winter.

Among the largest flowered orchids are Cattleyas [28], purple in one of its many shades being the predominating colour. Many of them will thrive in the coolest part of the hothouse, and they can be grown by planting the pseudo-bulbs in pots, half filled with drainage as recommended for the Calanthe and the remainder a mixture of leaf mould or peat and moss. In their youngest stages they like shade, but as they progress they should be brought into full light and air. After blooming they should be given very little water during the time they are resting. Very closely allied to the Cattleyas are the Lælias, the culture of which is similar in every way, and there are many hybrids between the two families, known as Lælio-Cattleyas. There is a good market demand for Cattleyas. This demand fluctuates a good deal, and the prices change also, but six shillings a dozen blooms is quite an ordinary figure—they sometimes fetch double that price.

One of the easiest grown orchids is Cœlogyne, a variety of which, Cristata, with pure white flowers, is the most useful orchid that can be grown in a small house, or where space is limited, as the flowers are borne so abundantly. The orthodox orchid potting mixture of peat and moss suits the Cœlogynes admirably, and the practice recommended for the Calanthes, of gradually increasing the quantity of water as the plant grows, and decreasing it afterwards, should be carried out.

Cypripediums are more familiarly known as "The Lady's Slipper Orchids" [27], on account of the peculiar pouch which is a prominent feature of the flowers. They are a popular buttonhole flower, and there is hardly a month of the year when one or other of the varieties cannot be had in flower. The mixture of soil already recommended suits them, and they like one of the hottest corners in the house, protection from the direct rays of the sun, and plenty of water all the year round. Care must be taken with the drainage of the pots, however, in order that the water does not remain stagnant about the roots of the orchid, for this is fatal. They usually fetch about 3s. or 4s. per dozen blooms in the market.

Although the Odontoglossum numbers among its varieties the most expensive kinds, there are plenty of others quite within the reach of the very smallest grower of orchids. They may be given the coolest corner of the house; in fact, some of them—notably Crispum—will flower in the greenhouse.

An orchid family most remarkable for its long sprays of flowers, which, in the majority of cases, hang downwards, in graceful showers, is Oncidium. Oncidiums will grow almost as readily in ordinary well-decayed leaf mould as in the orchid mixture.

Members of the following families of orchids are the others most generally met with in large collections, and the broad rules of culture laid down will be found sufficient in most instances: Cymbidium, Epidendrum, Habenaria, Lycaste, Masdevallia, Maxillaria, Miltonia, Phalænopsis, Stanhopea, and Vanda.

Continued

CAN THE MIND KNOW ITSELF?

The Eternal Question—What Are We? Relation Between Mind and Body. Does the Mind Influence the Body or the Body the Mind?

Continued from page 6470

By Dr. C. W. SALEEBY

PRAGMATISM amounts to this in practice, that you are to make up your mind as to what you want in the way of a creed, and see that you get it. Whatever you want to believe, whatever suits you to believe, that is truth for you, proving its truth by its suitability. Quite evidently this involves the utter destruction of the idea of truth at all. Absolutely opposed beliefs may suit one man and his neighbour respectively, and each is, therefore, on the pragmatic principle, true or as true as may be. "But they cannot both be true," says the smallest child—thus showing how deep the belief in the consistent One is planted in the constitution of mankind—and the pragmatist in his heart of hearts agrees with the child.

The Essence and Humour of Pragmatism. If only the pragmatic argument could be confined just to those beliefs which we want to have established! But unfortunately it cuts both ways, and the pragmatic argument which you adduce as the final warrant for your belief is precisely applicable to the case of your neighbour who finds that the negation of that belief is what suits him. Thus white is white if you like to think it white, but of course, if you so prefer, black is white—"if you do not see what you want in the window, please step inside," we will find something to suit your measure. Here verily is that royal road to learning the existence of which old Euclid denied. Truth is now a matter of taste. You need not go to seek her, she will always come to you. Nothing is either true or false, but thinking makes it so. That is pragmatism. It is quite the best joke in the history of philosophy. But at least let us attempt to learn one useful lesson from the pragmatist. Is it possible to say what it is that they have confused with truth? The answer to this is possible. That which the pragmatist confuses with truth is *value* It is perhaps the profoundest conviction of the philosopher that, at the last, when all secrets are unveiled, the true and the valuable will be found absolutely to coincide. But let him who thinks that they have always coincided glance but for a moment at human history and see how strangely it contradicts his assumption.

Mind and Brain. Having paid so much attention to the history of criticism in philosophy, let us turn to the main philosophic problem as it presents itself to us to-day. Someone has said that the proper business of philosophy is not to answer our questions, but to teach us how to ask them. That saying may be applied, perhaps, to the case of philosophy as we see it to-day. Perhaps it has answered no question since its dawn, but at least it is teaching us how to ask our questions, and that is a magnificent service to the intellect of Man.

We have agreed, have we not, that the problem of philosophy, with its inevitable belief in Oneness or Monism, is to explain the apparent dualism which existence presents to us—the dualism of mind on the one hand and not-mind on the other hand. We have traced throughout the generations various stages of the attempt to resolve this dualism, and we have hinted, perhaps, that both the materialists and the idealists may have been somewhat too ready to assume that one or other of the terms of the dualism was an ultimate. Let us now return to this question, and pose it in the form that most clearly states the issue. This form is undoubtedly "Mind and Brain."

The Nonsense Caused by Confusing Terms. The brain, of course, is a material thing which may be seen and handled and cut—or, as in the case of the calf, may even be eaten. Very few of us, however, can be accounted guiltless of the monstrous error of speaking of mind and brain as if they were interchangeable terms. This absolutely indefensible confusion of thought leads to such ludicrous results as the following, which is taken from a recent American author: "The modern scientific definition of mind is that part of the sensorium capable of the greatest molecular activity." This unfortunate writer has achieved the triumph of superseding the ordinary materialistic view that the mind is a product of the brain, by the magnificent fatuity that the mind *is* the brain. Thus, if you find that part of the sensory area of the brain which is "capable of the greatest molecular activity," and if you cut it thin and put it under the microscope and draw what you see, you will have the pleasure of cutting and drawing a piece of mind itself; or, if you desire your intelligence to develop, you might eat it, for what could possibly serve your purpose better than a diet of mind itself, unless, of course, mind happens to be tough and indigestible?

This is the sort of nonsense that follows from the use of the words mind and brain, as if they were one and the same thing. It is one more illustration of the manner in which we are deceived by language.

If We Could See the Brain. Here is the place to quote one celebrated argument of which those who think that the mind is the brain are apparently ignorant—an argument which, simple though it be, is seen to be more and more significant the more we think about it. We may quote it from Professor Mitchell, of Adelaide, the most recent writer on the subject.

"Adapting an old illustration, let us suppose that we had the means of so magnifying

the brain—each examining his own brain in a mirror, if you like—that its minute structure, and every movement in it, became visible. We are assuming that the effects of a stimulus upon it would be seen as a continuous series of physical changes in which the total energy is accounted for at every point by the work done (including the potential energy of new structural arrangements) and heat. At some point in the series, where the cerebral cortex is involved, we should see the various actions on which the course of feeling depends. We should not see the feelings; they would be something of which we had no sensation, something over and above the physical process. If the brain we examined were another's, we could only know of his feeling, say of red, from himself; if it were our brain, we should at the same time have the feeling of red, and see its immediate physical correlate, but our feeling of red we should not see."

A Monstrous Doctrine. This is surely clear enough. The only explanation of the fact that any contemporary writer should think that the mind *is* the brain must be an ignorance of the literature of the subject so great as to make this argument unknown to him. The argument shows that even the simplest of psychical facts, a mere uncomplicated colour sensation, cannot possibly be explained away in terms of the physical: it would still remain unreckoned with, even if we could watch every movement of the atomic dance within our heads. If this be so of a mere sensation, what shall we say of such a psychical fact as self-consciousness? How much the more monstrous must not the doctrine be which involves the proposition that my recognition of myself *is* the movement of atoms within my brain!

It is worth while to hold clearly to the distinction between the nervous system, or the brain, and the rest of the body, never losing sight of the fact that the brain is a material thing, as is the rest of the body. The initial recognition of this bodily division is all-important because of its bearing upon the theory of interaction between the psychical and the physical. There are innumerable cases familiar to all of us which seem to illustrate this interaction—as, for instance, when depression causes dyspepsia or dyspepsia causes depression. These are instances of the action of the mind upon the body or the body upon the mind, and unless they are more closely examined, they lead us to the apparently simple, but actually inconceivable, belief in causal interaction between the physical and the psychical. If, however, we insert this conception of the body as divided into brain and not-brain, we can express such instances in reasonable language. We then find that they are all within the realm of the physical.

The Relation between Mind and Brain. Let us take it that our problem may be confined to the brain and the mind. This physical brain may have been in many ways modified by physical causes without it. We fully recognise the action of such physical causes, but we have also to recognise that this demonstration of the action of the physical upon the physical tells us nothing as to whether the physical can act upon the psychical.

Now let us address ourselves with minds undeceived to the question of the relation between mind and brain. And here, fortunately, it is possible to state the various theories in self-explanatory language. What are the conceivable relations of the psychical and the physical? Well, in the first place, there is the relation of interaction, and that is, properly enough, expressed by the phrase *Psycho-physical interaction.* Over and against this phrase we may set another, which is of extreme importance in current philosophy, and is known as the theory of *Psycho-physical parallelism.* Now we must attempt to discuss the arguments expressed by these two phrases. Obviously, we must begin with psycho-physical interaction, one form or other of which has been believed by the vast majority of men ever since men began to think at all. Our previous discussion must already have made it quite clear to us that if there be any interaction it may act in either or both of two ways.

The Three Theories of Mind and Body. On the one hand, there may be interaction from the physical to the psychical—physical causes producing psychical effects. That, of course, is the view of uncritical common-sense, and it is the basis of all forms of materialism. On the other hand, there is that theory of interaction which asserts that psychical effects can produce physical causes, as expressed by our old friend, the phrase about the "influence of the mind upon the body." And, thirdly, of course, we may boldly brush aside the difficulties involved in each of these conceptions, and declare that interaction in both directions is possible. The mind can produce physical or brain changes, and changes in the brain can produce mental or psychical changes.

This is all very well so far, perhaps, but philosophy, profoundly distrustful of the unexamined opinions of common-sense, begins to ask inconvenient questions, and these are based upon that fundamental idea which we call the idea of causation. Can we really conceive at all, asks philosophy, that a sequence of material events should cause another sequence of events which belong to the psychical? That is what materialism asserts, and yet we find that the most thoughtful of the so-called materialists avow the absolute impossibility of accepting such an idea. Our conception of causation fails us. In a sense we can understand how a billiard ball may push another billiard ball, or an atom another atom, but the passage over from the collision of atoms within the brain to the psychical we cannot bridge.

Professor Tyndall's Incomprehensibles. There is a classical passage from Professor Tyndall which expresses this difficulty in the clearest and most authoritative manner. In allusion to the *conscious automaton* theory of Huxley, which we briefly stated in the course on PSYCHOLOGY, Tyndall wrote:

"Do states of consciousness enter as links into the chain of antecedence and sequence, which gives rise to bodily actions, and to other states of

consciousness; or are they merely *by-products*, which are not essential to the physical processes going on in the brain? Speaking for myself, it is certain that I have no power of imagining states of consciousness, interposed between the molecules of the brain, and influencing the transference of motion among the molecules. The thought 'eludes all mental presentation,' and hence the logic seems of iron strength which claims for the brain an automatic action, uninfluenced by states of consciousness. But it is, I believe, admitted by those who hold the automaton theory that states of consciousness are *produced* by the marshalling of the molecules of the brain, and this production of consciousness by molecular motion is to me quite as inconceivable on mechanical principles as the production of molecular motion by consciousness. If, therefore, I reject one result, I must reject both. I, however, reject neither, and thus stand in the presence of two Incomprehensibles instead of one Incomprehensible. . . . I bow my head in the dust before that mystery of mind which has hitherto defied its own penetrative power, and which may ultimately resolve itself into a demonstrable impossibility of self-penetration."

Materialism Refuted by Physics. This passage may well be submitted by the serious student to the callow writers who can swallow whole the ordinary materialistic belief without beginning to recognise how monstrous it is. Tyndall had every kind of motive to induce him to accept the materialistic hypothesis. It is not merely that he had freed himself from bias against it, but that all his bias was for it. He was, of course, one of the greatest physicists of the most wonderful century in the history of physics. When he declares that the production of consciousness by molecular motion is to him "inconceivable on mechanical principles," the assertion is that of one who really understands mechanical principles.

Nor must it be for a moment thought that this declaration was some personal eccentricity of Professor Tyndall's. On the contrary, it is the inevitable conclusion to which physical science is forced. These questions are often discussed by people such as Vogt, who depend for their scientific information entirely upon hearsay. Such an imbecile assertion as that the brain secretes thought as the liver secretes bile could only be made by one from whom the principles of the physical sciences were utterly hidden.

Materialism Inconceivable on Mechanical Principles. Mind, whatever it is, is demonstrably no form of physical energy—as we have seen. If it were produced in the course of physico-chemical changes in the brain and as the effect of those changes, then all the physicists' conceptions of energy and its conservation would be invalidated. The physics and chemistry of the brain constitute a complete system in which the laws of the conservation and transformation of energy are observed just as they are in a test tube. That may not yet be a fully demonstrated fact, but every materialist is bound by his own hypothesis to believe it. But this belief as such involves and necessitates a denial of the assertion that anything more than physico-chemical effects are produced; else something is being made out of nothing and we are talking babble. The materialistic theory of mind, which asserts that, though the physical series is complete and closed within itself, yet mind is produced by it, is "inconceivable on mechanical principles."

Mind and Body Interaction Inconceivable. Equally inconceivable is the production of molecular motion by consciousness, as suggested by the common phrase "the influence of the mind upon the body." This suggests the incursion of something from without into the physical series of transformations of energy. Either this something from without does nothing at all or else it must disobey the law of the conservation of energy. It must either create energy or destroy it—which every materialist, like every other student of the physical sciences, is bound to deny.

Thus, every form of the theory of psycho-physical interaction is incompatible with the law of the conservation of energy. That and that alone is a fatal argument against any such theory.

The second argument, which has already been referred to, is really more fundamental still. It depends upon that analysis of our ideas which shows that we cannot really conceive of such interaction. True, we may think that we can imagine it, but that is only because of the carelessness of our minds. The time has not yet come when men will cease to be contented with what Herbert Spencer called "pseudo-ideas." This of psycho-physical interaction in any of its forms is a pseudo-idea. The words expressing it can be put together in a grammatical form, so as to make a sentence which can be parsed and analysed and which may sound as if it meant something intelligible.

False Ideas. Yet if we come to look at it more closely, such a sentence contains nothing any more conceivable by us than the pseudo-idea of a "moral fluid" or a "square thought." Just as we really cannot conceive of the movement of billiard balls or atoms producing consciousness, so we cannot conceive the generation of motion in a billiard ball by an idea. We are mistaking mere combinations of words for rational concepts. "How can anything impalpable, non-material, utterly distinct from anything palpable or material, be the cause of changes in a material thing? 'Which of you by taking thought can add a cubit to his stature?'" Even if the law of the conservation of energy were not there, defying us to assert that mind can create or annihilate energy, the very laws of thought forbid us to entertain, except as a mere verbal proposition, the notion of psycho-physical interaction.

A curious comment upon the fallibility of our minds is constituted by the fact that there are many people who think they can entertain the notion of psycho-physical interaction from the

physical to the psychical—that is to say, from brain to mind—but who quite agree that the notion of any interaction in the other direction—that is to say, from mind to brain, is unthinkable. "They think they have no difficulty in conceiving how the redistribution of a number of atoms in the brain can cause the production of ideas. But a moment's consideration will show that if the one notion is untenable so is the other. If an atomic collision can cause an idea, then an idea can cause an atomic collision; but, as we now see, idea and collision are in different worlds."

Equally curious is the existence of other people whose opinion is precisely the reverse. They hold that "the action of mind on matter is the only kind of action or causation that we are capable of understanding."

The Extreme Theories. Finally, it is evident that if we reject as inconceivable (and as, even if conceivable, contradicted by mechanical principles) interaction in either direction, we reject still more summarily the easygoing views of those who hold that interaction between mind and brain in both directions is an obvious and commonplace fact. But before we pass on to the more modern theory of psycho-physical parallelism, we may briefly observe how the theories of interaction may develop at their two extremes. At the one extreme is the solution of idealism, which is not merely content to assert an action of mind upon matter, but declares that matter is actually nothing more than a convenient fiction of the mind: "into the man's head the whole world goes, including the head itself." At the other extreme is the notion of Huxley, already referred to, which goes one better than the assertion that matter can act upon mind, and declares that the psychical manifestations which accompany brain activity are mere accidents. They "are somehow thrown off from the brain, like sheets from a printing-press, and they are barely formed when they pass into nothingness, being too ephemeral to remain anything at all or make a difference to anything else. They are likened to words from our mouth, to the shadow and to the whistle of a passing train and to whatever is incidental and easily disappears." (Mitchell, "Structure and Growth of the Mind." Macmillan, 1907.)

The Physical and Psychical are Parallel. If, then, we are to reject any form of the belief in interaction between the physical and the psychical—that is, between mind and brain—and if we are not to ignore the indisputable fact that there is some kind of relation between them, there remains only one possible escape from our difficulty—if it is really an escape—and that must consist in the assertion that the relation between psychical and brain states is one not of dependence nor interdependence but parallelism. Two other modes of expressing this theory may be quoted: "The two kinds of events or processes in consciousness form two series that run parallel to one another, but never meet or interact." Or better still, since it hints at a philosophic conclusion: "The physical and the psychical are two modes in which one series of real events appears to us, and therefore the two series of appearances run parallel to one another."

The advantages of this mode of statement are that it by no means questions, but on the contrary emphasises, the indisputable fact that mind and brain *are* related; whilst, on the other hand, it avoids the difficulty of pledging us to any of those kinds of psycho-physical interaction which, as we have seen, do not admit of rational conception at all.

The Philosophic Inference. And now it is our business to observe the philosophic inference from this which seems to be the most warrantable conclusion of psychological science. It is the conclusion which has already been hinted at. We are not warranted either in regarding matter—for instance, the brain—as an ultimate, nor yet in regarding mind as an ultimate. On the contrary, mind and brain—that is to say, mind and that particular part of not-mind with which it is most commonly associated—are to be regarded as the correlative and proximate expressions for us of a One Something that lies behind them. Our analysis and recognition of this proximate dualism involves a monism beyond it. Mind and matter are related. We deny that there is any interaction between them, though we assert an absolute parallelism between them. Palpably this leads us to the inevitable conclusion that, as has been said before, they are the "subjective and objective faces of the same fact." That same fact, need we say, must be the ultimate reality of which philosophy is the quest.

Indeed, there can be no more important argument for the theory of psycho-physical parallelism, than the fact that it leads us directly to monism. Materialism and idealism led us to monism by denying respectively what seems impossible to deny—mind in one case, and matter in the other.

Our Knowledge of the Eternal. Short of these solutions there seemed to be no choice but to reject our ideal of monism altogether, and to rest discontent, with a "disastrous dualism." The whole story of existence must then be conceived in terms of a constant battering and interaction between these two irreconcilables. But when further criticism leads us to see that this interaction is as inconceivable as a constant relation is undeniable—then we are forced to the conclusion that our dualism is only proximate, and that mind and matter—or "mind and brain," or "mind and not-mind"—are like the concavity and the convexity of a curve, different aspects of one fact.

And if that one cannot be known and seen face to face by us—by us who are so bound that our belief in the existence of another's consciousness is only an inference from the material facts of his behaviour—what may fairly be inferred from our knowledge of its manifestations? We need not here concern ourselves with the names under which this one has been described by various thinkers. The Absolute of Hegel, the Substance of Spinoza, the Ineffable of many a poet, the Unspeakable of St. Paul, the Unknowable of

Spencer, the Unconditioned of Hamilton, the Nature of the pantheists—all of these correspond with an endeavour to express some aspect or other under which this inaccessible yet omnipresent eternal presents itself to us. Let us here contemplate what is in modern thought the noblest and most celebrated expression, in a poetic form, of the existence of this ultimate. It is taken from the lines "Composed above Tintern Abbey," by William Wordsworth, then aged 28:

"And I have felt
A presence that disturbs me with the joy
Of elevated thoughts; a sense sublime
Of something far more deeply interfused,
Whose dwelling is the light of setting suns,
And the round ocean and the living air,
And the blue sky, and in the mind of man;
A motion and a spirit, that impels
All thinking things, all objects of all thought,
And rolls through all things."

Knowledge Lives—Shall That which Knows Die? But apart from the more or less poetic names given by the philosophers, and from the poetic expression of Wordsworth, how much are we entitled to set forth as our warrantable and rational knowledge of something beyond? At least we are entitled to make what inferences we may from our knowledge of its phenomena. We have agreed already that it is one and consistent. There are not many realities but one reality—in the last resort not many incomprehensibles but one incomprehensible.

Again, all our physical sciences, in their close study of phenomena—that is to say, of one aspect under which reality expresses itself to us—warrant the conclusion that reality is "eternal and uncreated." Ceaseless change there may be and is—change the best sign of vitality—but there is neither creation nor annihilation. Hence there spring to our minds the words from the Athanasian Creed: "eternal and uncreated," reminding us of the words of the psalmist, "from everlasting to everlasting thou art God."

Furthermore, this conception of indestructibleness has its immediate bearing upon the question of the Hereafter, as to which science knows only that she can neither affirm nor deny; but she is bound to listen to the famous question asked by Shelley as he mourned the untimely death of his friend Keats:

"Nought, we know, dies. Shall that alone which knows
Be as a sword consumed before the sheath
By sightless lightning?"

A Mighty Conception. One, eternal, uncreated—but not intelligent; such has been the amazing conclusion of some. The reality which can manifest itself as intelligence is itself non-intelligent! Can any more ludicrous belief be conceived? If mind exists at all, that in which it lives and moves and has its being must be at least no less than mind. Rather must we incline to the belief that the "infinite and eternal energy from which all things proceed" "wells up in ourselves in the form of consciousness"; palpably it is monstrous to regard reality as lower and less than one of its own manifestations. Yet there remains the highest conception of all, the mightiest thought of an all but peerless mind. "Is it not possible," says Herbert Spencer, "that there is a mode of being as much transcending Intelligence and Will as these transcend mechanical motion?"

Here, perhaps, we have reached the highest of the uses of philosophy. Let us summarise the forms in which it has worth for us, directing our summary against certain recognised criticisms. These are, in the first place, that philosophy reaches no conclusion. Then, in the second place, there is the criticism that philosophy has taken away men's activities from this world in which we live—which still has need of every fine mind and energetic spirit. Lastly, there is the criticism that even if the answer of philosophy were obtainable or obtained, it is not necessary. As Goethe hinted, man was born to live his life and not to solve the problems of existence.

What, then, is our reply to these criticisms? In the first place, we may make small points as that the study of philosophy helps to train the mind, and then we may go on to something more substantial. We may point out that, even if philosophy returns no final and complete answer to the world riddle, at least it refutes the shallow conclusions of those who think that they have found the answer. Now that is a very great service indeed, and if the study of philosophy had done nothing more, this would have been sufficient to justify it.

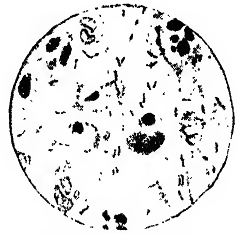
The Service of Philosophy to Religion. Without philosophy there would be the gravest risk that the common run of scientific students should forget the limitations under which they work—should imagine that their atoms and forces and cells and metabolisms were ultimates, and that their conclusions were final and complete instead of being merely proximate, tentative, and symbolic. So long as men go on thinking, the services of philosophy will be necessary in order to remind them that upon merely phenomenal knowledge no warrant can be grounded for denying the reality of truths that lie beyond the grasp of any phenomena. And plainly, these services of philosophy, as the necessary critic of science, constitute on the other hand, and more positively, a service to religion itself.

Philosophy also has its constructive side, and it is this which comprises its service to religion. Have we not seen that there is philosophic warrant for certain, at least, of those ideas which, apart from philosophy, can be reached by faith only? Plainly, if rational support can be found, for instance, for such an expression of the poet as "from Everlasting to Everlasting thou art God"—plainly that is a very real service of philosophy. No less is the service if, when science, so critical, has succeeded in destroying certain of our religious conceptions, and thereafter would persuade us that beyond the visible and the transient there is nothing—if, then, philosophy should teach us and compel us to believe that beyond the visible and the transient, behind the mind itself, there is and remains an Eternal Power which "rolls through all things."

PHILOSOPHY *concluded; followed by* RELIGION

TUBERCLE BACILLI IN SPUTUM
× 700

PNEUMOCOCCI
× 700

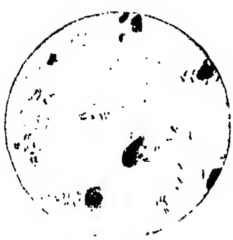


BACILLUS COLI COMMUNIS
× 700

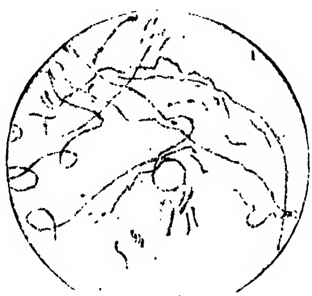
ANTHRAX BACILLI FROM CULTURE
× 700

TYPHOID BACILLI
× 900

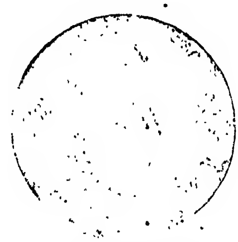
STREPTOCOCCUS PYOGENES
× 850



MIXED INFECTION
STREPTOCOCCI, BACILLI, AND STAPHYLOCOCCI

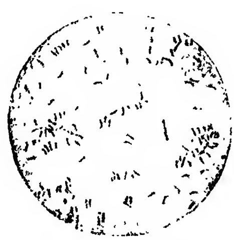


BACILLUS SUBTILIS. CULTURE
× 700



COMMA BACILLUS OF CHOLERA
× 700

ANTHRAX BACILLI. SPLEEN
× 700



TYPHOID BACILLI. CULTURE
× 700

ORGANISMS IN PNEUMONIA SPUTUM
× 750

8. SOME DISEASE-PRODUCING MICROBES AS SEEN UNDER THE MICROSCOPE

IMMUNITY FROM DISEASE

Bacterial Sewage Disposal. How Microbes Cause Disease and their Products End it. Microbe-digestion. Natural and Acquired Immunity

By Dr. GERALD LEIGHTON

WE have already seen that the natural processes which break up organic material are of a microbic nature, and during recent years the opinion has been growing that advantage should be taken of this fact in order to dispose of the organic material in sewage. The idea is to imitate Nature in this matter as closely as possible. We know that some bacteria exist naturally in sewage, where they break up organic compounds, converting the nitrogen into nitrates and nitrites. It would therefore appear that the most reasonable way of disposing of sewage would be to encourage the growth of such bacteria as are naturally present.

The Bacterial Treatment of Sewage.

The method adopted, speaking generally, is given in the following paragraphs. [See also CIVIL ENGINEERING, pages 4742 and 4821.]

"It is usually effected by running the sewage on to beds of coke, allowing it to stand for some hours, slowly running the effluent out through the bottom of the bed, and leaving the bed to rest for some hours before recharging. The final result is better if the effluent be afterwards run over another similar coke-bed. According to some authorities, the sewage, as it runs into the first bed, takes up from the air considerable free oxygen, which, however, soon disappears during the stationary period, so that on leaving the first bed the sewage contains little oxygen. In the latter part of its stay it has thus been submitted to anærobic—that is, without oxygen—conditions. Further, while by the passage of the effluent out of the first bed oxygen is sucked in, it rapidly disappears, and during the greater part of the resting stage the interstices of the bed are filled with carbonic acid gas, with nitrogen, partly derived from the air, partly from putrefactive processes, and thus in the filter anærobic conditions prevail, under which the bacteria can act on the deposit left on the coke. . . . Probably the best results in sewage treatment are obtained when it is practicable to introduce a step where there can be no doubt that the conditions are anærobic. This involves, as a preliminary stage, the treatment of the sewage in what is called a septic tank, and the method has been adopted at Exeter, Sutton, and Yeovil, in this country. . . .

"In the explanation given of the rationale of this process, sewage is looked upon as existing in three stages. First of all, *fresh sewage*—the newly mixed and very varied material as it enters the main sewers. Secondly, *stale sewage*—the ordinary contents of the main sewers. Here there is abundant oxygen, and as the sewage flows along there occurs, by bacterial action, a certain formation of carbon dioxide and ammonia, which combine to form ammonium carbonate. This is the sewage as it reaches the purification works. Here a preliminary screening may be adopted, after which it is run into an air-tight tank—the septic tank. Thirdly, it remains there from 24 hours to 36 hours, and becomes a foul-smelling fluid—the *septic sewage*. The chemical changes which take place in the septic tank are of a most complex nature. The sewage entering it contains little free oxygen, and therefore the bacteria in the tank are probably largely anærobic, and the changes which they originate consist of the formation of comparatively simple compounds of hydrogen with carbon, sulphur, and phosphorus. As a result, there is a reduction in the amount of organic nitrogen, of albuminoid ammonia, and of carbonaceous matter. The latter fact is important, as the clogging of ordinary filter beds is largely due to the accumulation of such material, and of matters generally consisting of cellulose. One further important effect is that the size of the deposited matter is decreased, and therefore it is more easily broken up in the next stage of the process. This consists of running the effluent from the septic tank on to the filter beds, preferably of coke, where a further purification process takes place. By this method there is, first, an anærobic treatment, succeeded by an ærobic one; in the latter, the process of nitrification occurs by means of the special bacteria concerned. The results are of a most satisfactory nature.

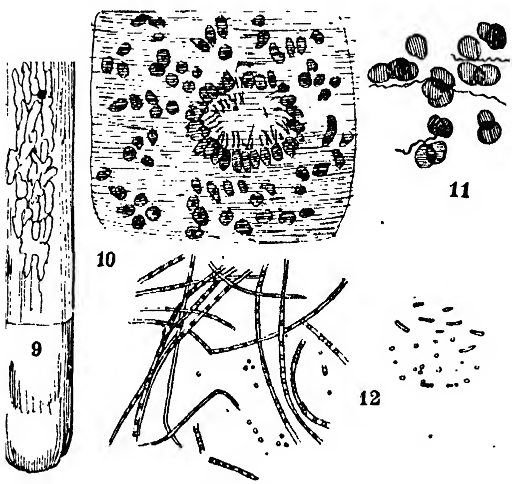
"Sometimes the effluent of a sewage purification system contains as many bacteria as the sewage entering, but, especially by means of the septic tank method, there is often a marked diminution. It is said by some that pathogenic bacteria do not live in sewage, but in an effluent Bacillus coli, B. enteritidis, and streptococci have been constantly found, so that the observation is of little value, and it is only by great dilution and prolonged exposure to the conditions present in running water that such an effluent can be again a part of a potable water." (Muir.)

The Relation of Bacteria to Disease.

We must now turn our attention to the special point to be dealt with here—the relation of microbes to the existence of disease, perhaps the most fascinating study in connection with medicine and pathology. Our illustrations [**8** to **16**] show some of the more common and important disease-producing germs, as well as their methods of culture. The cholera bacillus [**13**] is shown in two stages of growth in nutrient gelatin, which it is liquefying as it grows [**16**]. It is also shown *in situ* in the intestine, where it is producing its effects [**14**]. The deadly germ of anthrax and wool-sorter's disease is seen as it appears when sporing [**12**]. The germ of tuberculosis (the tubercle bacillus) is shown growing in blood serum [**9**], and also as it is sometimes found in a "giant cell" in the tissues, a large cell produced in tubercular areas [**10**]. Another organism, of the spirillum shape, is that of the disease called relapsing fever [**11**]. These, together with the various forms of cocci found in suppuration, illustrate the most important kinds of germs associated with the common diseases.

We have already realised the omnipresence of microbes around us—that some are innocent or useful, and others pathogenic. It now remains to see how the disease-producers do their deadly work; how they gain access to the individual; how he resists their attacks, and how he may become immune to their ravages.

How Microbes Enter the Body. In order that a microbe can adversely affect a person, it must first of all get *on to* or *into* his body tissues and act upon them. No germ arises *de novo*; every microbe springs from a pre-existing one. The popular idea that a defective drain will cause microbes to come into existence is a pure myth: all it does is to provide a suitable nidus for germs, already present, to grow and multiply there. A microbe may get on to the surface of an individual, on to his skin, by actual transference from the skin of another person, by contact or contagion. Once on the skin, the microbe must gain further entrance through some scratch or abrasion, in most cases, before it can do any harm. (We are not now referring to small animal parasites, such as that of itch, which burrow in the skin, or those which attack hair.) The healthy unbroken skin is an effective barrier to germs, else we should never be safe from their presence. But once the microbe has passed this barrier, many ways are open, all of which involve serious results. The germ may settle down at the point of entrance, there multiply and produce its poison or toxin, which is absorbed into the system, and kill the patient without further invasion. This occurs in tetanus or lock-jaw. Or, having passed through the skin, the germ may pass into the blood circulation or the lymphatic vessels [see PHYSIOLOGY], and be carried with great rapidity to every part of the body, multiplying as it goes and carrying the possibility of disease and death along its path. The organisms of suppuration spread thus, and produce abscesses wherever they settle in organs such as the liver and kidney, as well as at the point where they gained their first entrance.



TUBERCLE AND OTHER BACILLI

9. Tubercle bacillus in blood serum. 10. Tubercle giant cell with bacilli. 11. Relapsing fever bacillus. 12. Anthrax bacilli, showing spore formation

Other Paths of Invasion. Two other portals are open to the invasion of the army of bacteria — the digestive system through the mouth, and the respiratory system through the nostrils and mouth. Large numbers of germs are taken into the alimentary tract along with food and water, many of which do no harm at all; but many pathogenic ones also enter thus, and act either on the stomach or bowels, or gain entrance through the mucous membranes of these organs into the general circulation. Their results will be found mainly in the organs named, or the liver, and later on in the general poisoning of the whole system from their products. The typhoid bacillus is a case in point; it selects a special portion of the bowel for its chief site of operations, there producing the ulcers which constitute the great danger of that condition. In this case, contaminated food or water is the usual carrier of the germ.

The third great path of invasion is through the breathing passages into the lungs. Many microbes or their spores float about in the atmosphere, and are inhaled during the act of breathing, and some of these air-borne germs are active agents in the production of disease—for example, the bacillus of consumption and that of wool-sorters' disease. The germ of consumption is coughed up by tubercular patients and expectorated upon the pavements, where, after the moisture of the sputum is evaporated, it is left dried, carried about by the air, and inhaled. It is for this reason that spitting in public places should be and is prohibited by law.

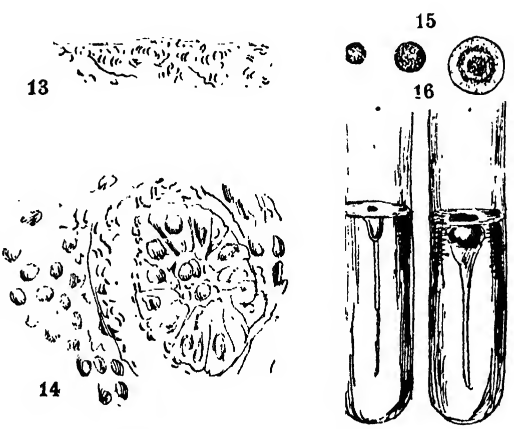
The question which at once suggests itself from these facts is, "How does anyone escape infection, since pathogenic germs are apt to attack individuals from all these sources?"

How we Escape the Attacks of Microbes. It is quite obvious that were there not some means of repelling the attacks of the microbes all around us no one would escape infection. In other words there must exist in human beings some degree of natural resistance to these attacks, a resistance which is born with the individual, without which he could not live. And this is actually the case. This resistance is termed *natural immunity* or innate immunity, because it is inborn. The phrase introduces us to one of the most important words in the whole of natural science, the word *immunity*. This word must be clearly understood if we would understand life itself in any way. Immunity is the key which unlocks almost all the important problems which a man has to settle for himself in every sphere, be it physical, mental, moral, or religious. It is, or should be, his aim in life to become immune to all agencies of whatever nature which threaten his existence or his perfect development in any of these spheres. There is nothing of so great importance. The most perfect character ever known in the history of the world was so in virtue of His immunity to sin. The healthiest man that lives is so in virtue of his immunity to disease. We must, therefore, carefully define the term, and thoroughly grasp its meaning.

What is Immunity? It will conduce to simplicity if we consider immunity first of all simply from the point of view of disease, carefully remembering that this is but one phase of a general principle. From this aspect we may define it thus: Immunity is that condition of an individual, an organ, or a tissue, in virtue of which infection can be partially or absolutely resisted. Let that definition be read several times and let the reader ponder it carefully, grasping its full significance before proceeding with the consideration of this vital matter. Immunity is that condition of ourselves which enables us to keep free from infection, either entirely free or comparatively so. In

other words it enables us to resist attack. Without it all would become infected and none could resist when attacked. Life would be impossible, for life itself is the sum total of our immunities. In the sphere of disease, total immunity means complete insusceptibility to a given disease, whether under natural conditions or from artificial inoculation. Immunity from disease is therefore the great aim of modern scientific medicine. If not possessed naturally, the next best thing is to acquire it artificially in some way, which we shall consider in a moment. For the present we are concerned with natural resistance.

Examples of Natural Immunity. Many examples of natural resistance to disease occur in man and the lower animals. Thus, human beings are immune from a disease which attacks pigs—namely, swine fever. They are naturally so immune simply because they are human beings. On the other hand the lower animals are absolutely immune from some diseases to which man is susceptible, such as typhoid fever and Asiatic cholera, neither of which attack animals under natural conditions. This does not mean that when the organisms of these respective diseases are introduced into the body artificially, no ill effects follow. It means that the characteristic symptoms and changes associated with the diseases in question do not appear.



CHOLERA BACILLI

13. Cholera bacilli. **14.** Growing in intestine. **15.** Colonies of bacilli on a plate culture. **16.** Cholera bacilli in gelatin

Natural immunity, therefore, varies with the species of animal under consideration; some species are immune from one infection, some from another. It also varies with different races of the same species. Thus, the various races of human beings, white and black, exhibit varying degrees of immunity from and susceptibility to the same diseases. So in the lower animals, such as sheep, the different breeds of which show varying degrees of resistance.

This natural, innate, or inborn immunity depends upon the power of certain cells and tissues and secretions in the body to overcome and destroy microbes which may gain entrance to the body.

As a matter of fact the tissues in the body have great power of destroying microbes during life. Natural immunity is therefore chiefly the power of resisting infection.

Natural Destruction of Bacteria. Two factors are mainly responsible for the natural destruction of living germs within the living body. The first is the action of certain body cells which attack germs; the second is the power of the blood serum to destroy them likewise. The cells which operate in this manner are called *phagocytes* (cell-eaters). Most of our knowledge concerning these is due to the splendid work of the famous pathologist Metchnikoff. He noticed that it was a very common property of animal cells that they could take up small particles into their interior and destroy them by digestion. On this fact he based his theory of *phagocytosis*, which implies that certain body cells thus take up and digest the germs of disease. The cells in the human body which do this are the leucocytes in the blood [see PHYSIOLOGY], and certain cells such as endothelium and those of connective tissue. The more active these phagocytes the greater the degree of immunity possessed by the individual, and vice versa. When germs enter the body they seem to attract the leucocytes towards them, and the greater this attraction the better for the animal, because the greater the destruction of the bacteria.

Secondly, it has also been shown that ordinary blood serum possesses the power of destroying various germs, and upon this fact is based the recent serum treatment of disease, in which the serum is made to acquire this power artificially against special diseases.

Acquired Immunity. In addition to this inborn or natural immunity which we have considered there is a second kind or type, which the individual acquires during his lifetime. Physicians have long known that certain diseases confer upon the individual who recovers from their attacks an absolute immunity from further attack for a longer or shorter period, in some cases for years, sometimes practically for a lifetime. Now, this immunity is something which the patient did not possess before. It is something new, acquired, and hence is termed *acquired immunity*. We see examples of this acquirement every day. It is observed in those who have suffered from smallpox, scarlet fever, and measles. It is extremely rare that anyone has these diseases more than once in their lives. This acquired immunity is not to be looked upon as the result of the disease as such; it probably depends in some way upon the products of the germs which are introduced into the system during the attack. In fact, by suitable administration of the products of bacteria, a very high degree of this kind of immunity may be conferred upon a person without his undergoing the disease and without the occurrence of any symptoms at all.

This acquired immunity may be obtained in various ways. When a person is vaccinated he is really inoculated with a modified small-pox germ product from the cow. The effects of this operation of vaccination are trifling if the vaccine be pure and the patient healthy, so trifling as to be of no account when compared with the terrible results of actual small-pox. Nevertheless, we find that the result of vaccination is to cause the patient to acquire a complete immunity from small-pox for a number of years. It is less lasting than recovery from the disease itself because the virus introduced is less potent.

It is too risky to inoculate from a small-pox pustule; the patient is immune if he recover, but he may very easily die. So the vaccine or lymph

is weakened or attenuated by passing it through another animal.

Acquired Immunity Ending Disease. "Recovery from an acute infective disease shows that in natural conditions the virus may be exhausted after a time, the period of time varying in different diseases. How this is accomplished we do not yet fully know, but it has been found in the case of diphtheria, typhoid, cholera, pneumonia, etc., that in the course of the disease certain substances appear in the blood which are antagonistic either to the toxin or to the vital activity of the organism. In such cases a process of immunisation would appear to be going on during the progress of the disease, and when this immunisation has reached a certain height, the disease naturally comes to an end. It cannot, however, be said as yet that such antagonistic substances are developed in all cases; and it is by no means the case that the degree of immunity is always proportional to the amount of these substances in the blood." (Muir.)

How Bacteria Cause Disease. It is convenient at this point to note that bacteria produce their effects by two distinct modes of action. First of all their action may depend upon their rapid multiplication in the body after gaining entrance, thus causing a rapid distribution of themselves throughout the tissues and a general infection. When this rapid multiplication occurs in the blood, the condition known as *septicæmia* is produced. Secondly, their chief effects may be due to their own chemical products, not to rapid multiplication of individual germs. These poisonous or harmful products are called *toxins*. These diffuse out from the bacterial cells into the blood or tissues, and produce effects upon the various parts of the body which are susceptible to the action of the special toxin developed. Thus, some toxins produce a high temperature or fever; others depress the action of the heart, causing cardiac failure; others, acting on special parts of nerves, cause spasms of muscles, while others act upon the tissues in their immediate locality, causing their death or necrosis. The results are, therefore, local (on the spot), or general (throughout the body).

What an Anti-toxin is. Bearing in mind these two methods of bacterial action, we may now return to the question of immunity. We see now what it is against which a patient must become immune in order to recover from an attack of an infective microbic disease. In order to resist infection he must be able to destroy, kill, or digest the actual germs which gain entrance to the body, and prevent their rapid multiplication in the tissues. In other words, he must have within him certain anti-bacterial or bactericidal (germ-killing) substances. These, we have seen, are leucocytes, other cells, and serum. But should these fail in their efforts to destroy the invading microbes; should these latter effect an entrance and begin to flourish in the body, producing as they do so their powerful toxins, then, in order to recover and become immune to further attack from the same source, something more is necessary. Not merely do the bacteria require to be killed, but their toxins must be neutralised in some way. Indeed, this is more important than killing the germs themselves. The physical effect of the presence of the microbe is trifling in comparison with the result of the action of the potent chemical toxin which it may produce. If this latter can be antagonised, the former in many cases is of little moment. Any substance which is capable of nullifying or antagonising the evil effects of a toxin is termed an *anti-toxin.* If this anti-toxin be contained in a serum from an animal the whole is termed *anti-toxic serum,* such as that which is used in the treatment of diphtheria and other microbic diseases whose worst action is that of their toxins.

In acquiring immunity from a disease as the result of recovery from that disease, as in small-pox or scarlet fever, the patient obviously manufactures for himself during his illness his own anti-toxin or anti-bacterial substance. Having manufactured it, it is available for future use, and protects him against further infection from a similar scourge. During the process of manufacture, he is more or less dangerously ill. It is for this reason that we must trust to artificial production of immunity in place of that conferred by recovery from disease; the latter is too risky, for the patient may die. Immunity is not so powerful when artificially conferred, but it is free from risk, and can be renewed when necessary. Hence it is made illegal to give people small-pox by inoculation, on the chance that they may recover and become immune, though this was done formerly. We use the artificial method of vaccination, which, though not quite so powerful, is harmless, and confers protection for some years.

Treatment by Anti-toxic Serum. All that is necessary is to find an animal which is susceptible to the action of the germs against which it is required to produce or acquire immunity. By various methods, the technical nature of which need not be discussed here, the animal is rendered immune artificially. That is to say, by carefully increasing the doses of germs the animal is gradually brought to such a stage that it can withstand the inoculation of a dose which previously would have proved fatal. The horse (in the case of diphtheria) has acquired immunity from the diphtheria germ and its toxin. Not only so, but it is found that the serum of such an animal contains the anti-substances ready made, and in such a form that they can be transferred from an immunised animal to another. The serum is anti-toxic, and it has merely to be drawn off and preserved in a sterile condition to be ready for use as an anti-toxic serum. Such a substance is a great advance upon such a method as vaccination, from one point of view—that it can be used as a *curative* agent immediately. Vaccine cannot be so used; it is a *preventive* agent. From its use the patient is enabled to make his own anti-toxin, but he must be free from the disease when he does this. Having done it, he is immune for years. With the anti-toxic serum, however, the doctor can attack a case of diphtheria actually in progress, because he has a weapon which contains the substances ready made which will neutralise the diphtheria toxins from which the patient dies. On the other hand, though he saves the patient's life, the injection of the serum does not confer immunity for long; it becomes eliminated from the body. The one may prevent death after the disease is in actual progress, the other prevents infection if used before exposure to infection. The future of curative and preventive medicine is wrapped up in the further elaboration of anti-toxic and anti-bacterial remedies, and considering what bacteriology has accomplished in this direction in a very few years, he would be a rash man who would venture to set a limit upon its future possibilities. Thus it will be realised that in the sphere of disease, as in all others, the great aim of man is to become immune from deleterious and destructive agencies.

Continued

A SHORT DICTIONARY OF BACTERIOLOGICAL TERMS

ACID-FAST—A term applied to those organisms which retain stains even though treated by decolourising acid solutions.

Actinomycosis — A disease most common in cattle, especially in the jaws, caused by the actinomyces or ray fungus.

Ærobic—A term applied to micro-organisms which require oxygen to enable them to grow.

Agar-agar—A substance prepared from the roots of seaweeds, used to solidify the medium in which organisms are grown.

Agglutination—The phenomenon observed when organisms are placed in a serum prepared from an animal immunised against similar organisms. The organisms thus treated are observed to lose their motility, and become aggregated or "agglutinated" into clumps.

Agglutinins—Definite substances in a serum, which causes the phenomenon of agglutination.

Alexins—Substances present in normal blood serum, which help to confer natural resistance to infection.

Anærobic—A term applied to organisms which will not grow in the presence of air.

Anthrax—An infective disease caused by the anthrax bacillus; communicable to man, in whom it causes woolsorters' disease of the lungs; malignant pustule in the skin.

Anti-bacterial Serum—A preparation of blood serum from an animal, which is destructive to certain microbes.

Antitoxic—Having the power of antagonising toxin.

Antitoxic Serum—A preparation of the blood serum from an animal, which antagonises the poison or "toxin" of certain microbes (*e.g.*, anti-diphtheritic serum).

Antitoxin—A substance which antagonises a toxin.

Attenuation—The process by which the virulence of a microbe can be reduced.

BACILLUS—Literally a small rod; a term applied to many organisms, which are of that shape.

Bacteria—Literally rods; but used to refer to micro-organisms in general.

Bactericidal—Having the power of destroying bacteria.

Beggiatoa—A group of organisms composed of indistinctly articulated threads, containing sulphur granules.

Blood Serum—A nutrient medium in which organisms are grown.

CHEMIOTAXIS—The name applied to the attraction or repulsion exercised upon bacteria by chemical agents (positive and negative chemiotaxis respectively).

Chromogenic—A term applied to organisms which produce pigment.

Cilia—Minute protoplasmic threads attached to the sides or ends of organisms, by means of which they move.

Cladothrix—A group of organisms in which there is an appearance of branching, really due to two terminal cells lying side by side.

Clubs—Elongated, pear-shaped bodies seen at the periphery of a colony of the actinomycosis parasite.

Coccus—A round organism occurring either singly, in pairs, in fours, in chains, or in bunches.

Colony—The term applied to a number of organisms growing together.

Complement—A substance developed during the process of immunisation.

Culture—The name applied to the growth of one single species of microbe when artificially cultivated.

Cytolytic Sera—Sera which are destructive to cells.

DIPLOCOCCUS—A coccus occurring in pairs.

Disinfectant—Any substance which has the power of destroying the life of microbes.

Drying—One method employed to weaken the virulence of organisms.

EHRLICH'S SIDE-CHAIN THEORY—The term applied to the recent theory advanced by Ehrlich to account for the formation of antitoxins in the body.

Enhæmospores—Spores found in the blood (as in malaria).

Exhaltation—The increase of virulence of microbes; the converse of "attenuation."

Exotospores—Spores occurring in the body of the mosquito; a stage in the life cycle of the malaria parasite.

FACULTATIVE—A term applied to organisms which can live either with or without oxygen.

Farcy—A form of glanders, affecting the lymphatic vessels and glands.

Fever—An abnormal rise of body temperature, frequently caused by microbes or their toxins.

Fission—A process of multiplication in microbes.

Flagella—Delicate protoplasmic threads [see *cilia*].

GELATIN—A substance used to solidify nutrient media.

Gentian-Violet—A stain much used to demonstrate microbes.

Gram's Method—A process of staining which differentiates certain organisms from others.

HÆMAMŒBA MALARIÆ—The parasite of quartan fever in man.

Hæmamœba Vivax—The parasite of tertian fever in man.

Hæmolytic Serum—The blood serum of one animal which has the power to a certain extent of dissolving the red blood corpuscles of another animal of different species.

Hæmomenas Præcox—The parasite of malignant or aestivo-autumnal fever of man.

Hydrophobia—An infectious disease occurring chiefly among carnivora, especially in the dog and wolf; transmitted by bite.

IMMUNE BODIES—Substances developed during the process of immunisation.

Immunisation—The process of rendering an animal immune.

Immunity—That condition of an individual, an organ, or a tissue, in virtue of which it is enabled to resist infection either absolutely or partially. Immunity may be natural or inborn, or it may be artificial or acquired. According to the means used for the production of immunity, it is active or passive. Active immunity is obtained by injections of organisms either attenuated or in sub-lethal doses; or, secondly, by injection of their products or toxins. Passive immunity is the injection of the serum of one animal, highly immunised by active immunity, into another animal, the latter being thus rendered immune.

Incubator—An apparatus used to cultivate organisms which require constant warmth.

Inoculation—The injection into an animal of microbes or toxin by means of a hypodermic syringe. Also, a means of separating one organism from a mixture of organisms.

LEUCOCYTES—White blood corpuscles, which act as phagocytes *i.e.*, they have the power of taking up microbes into their protoplasm.

Leucocytosis—An increase in the number of leucocytes.

Lysogenic Action—The destructive action of an anti-serum upon organisms. It is due to two substances the immune body and the complement, or alexin [see above].

MACROPHAGES—Any cells larger than the small leucocytes which have the power of ingesting bacteria.

Mallein—A substance used to diagnose glanders, prepared from cultures of the glanders bacillus.

Micrococcus—A general term applied to any small round microbe.

Microphages—The smaller leucocytes which ingest bacteria.

Myelocytes—Cells in bone marrow from which leucocytes develop.

NITRIFYING BACTERIA—Bacteria in the soil which make nitrogen more available for plant nutrition by conversion of ammonia into nitrites and nitrates. Others take up free nitrogen from air, and combine it into compounds.

OPSONIC INDEX—A means of stating the power of opsonins. The opsonic index is the ratio of the bacilli ingested by leucocytes incubated in the patient's serum to those ingested by an equal number of leucocytes incubated under similar conditions in healthy serum. Thus for tubercle bacilli the opsonic indices of healthy persons may vary from 0·8 to 1·2; in tubercular patients it may be as low as 0·3 or as high as 1·8.

Opsonins—Substances contained in blood serum which act upon bacteria rendering them more easily eaten by leucocytes. (From Greek words meaning "prepared for being eaten.")

PASSAGE—The process of passing a microbe through the body of an animal for purposes of attenuation or isolation.

Pathogenic—Productive of disease.

Pfeiffer's Phenomenon—A destruction of organisms by lysogenic action [see above] due to a specific substance in the serum.

Protective Inoculation—The conferring of immunity by active methods.

Ptomaines—Substances containing nitrogen isolated from putrefying matter or from cultures of microbes.

RECEPTORS—The name given by Ehrlich to groups of atoms with affinity for certain foodstuffs.

Ricin—A vegetable poison (allied to bacterial toxin).

SARCINÆ—Coccus-like organisms which divide in three axes at right angles to one another, usually seen in cubes of eight.

Septicæmia—A condition in which microbes multiply within the blood stream, and give rise to symptoms of general poisoning without the production of abscesses.

Spirilla—Organisms which are in the shape of cylindrical, wavy, or spiral cells.

Staphylococcus—A coccus which occurs in clusters.

Sterilisation—The process of rendering any substance free from microbes.

Streptothrix—An organism consisting of a mass of filaments in which true branching occurs.

TETRAD—The occurrence of an organism in fours (Tetracoccus.)

Toxin—A bacterial product of poisonous action.

Tuberculin—A curative or diagnostic agent for tubercular affections, prepared from cultures of the tubercle bacillus.

UNIT OF IMMUNITY—The amount of antitoxic serum which will neutralise 100 times the minimum lethal dose of toxin, serum and toxin being mixed, diluted, and injected subcutaneously. A normal antitoxic serum is one of which 1 c.c. contains an immunity unit

Group 10
ELECTRIC CABLES
1
Following TELEPHONES from page 6[illegible]

MAKING ELECTRIC CABLES

Varieties of Electric Cables. Conductors and Insulation. Making, Covering, and Testing Cables

FOR the distribution of electricity in large quantities, cables are in general use. The electrical cable is an insulated or separated artificial path or track along which electricity will flow readily. The path is a metal core, known as the *conductor*, and the material which separates it from the surrounding objects is known as the *insulation*. Copper has been found to conduct better than most other substances, hence we find the conductor in nearly all cables made of a copper-wire rope or strand. The insulation is a coating of a material which will not allow electricity to pass through, or along it, except under very great pressure; therefore, when this material is placed round the core, the current flowing through the conductor is entirely separated from objects around it, and is consequently under control.

Insulation. Insulations fall naturally into two classes: (1) *hygroscopic*, or moisture absorbing; and (2) *non-hygroscopic*, or moisture resisting. The more common of the first class are jute and paper, and of the second, vulcanised indiarubber, gutta-percha, and bitumen.

The first successful experiment in which a continuously insulated cable was used was in 1812, when Baron Schilling exploded a mine by electricity conveyed by a wire insulated with indiarubber, and laid across the River Neva. In 1815, or 1816, Ronalds carried out some experiments in telegraphy, and, in addition to an overhead wire, which was suspended by silk threads hanging from wooden frames, he laid one, a little less than a furlong in length, underground. This was drawn through glass tubes, the separate lengths of which were joined together by small glass sleeves placed over the joints and fastened in position with wax. The glass tubes containing the wire were then placed in a wooden trough and covered over with pitch. This method of insulation was not very successful, as the glass was very liable to break and leave the wire uninsulated. The stranding of wires was introduced when large sectional area and flexibility were required. In 1837, a line was laid in London in which the wires were covered with cotton steeped in resinous compound, and then laid in grooves cut in baulks of wood. The insulation of these wires soon gave way, because the cotton decomposed and left the wires practically bare. The dampness which caused the decomposition also acted as a conductor, and allowed the electricity to escape.

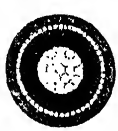
In the following year a line was laid from Paddington to Slough. In this instance the wood was replaced by iron pipes; but the line had the same fate as its predecessor, and an overhead system was substituted. In 1845, a proposal made by Wheatstone and Cook to enclose the cotton-covered wires in lead tubes, was a step in the right direction, and a patent was taken out in the same year for lead-covered wires. Cables covered with lead gave much better results than previous ones, and about this time a new insulation was discovered in gutta-percha, Faraday being one of the men who found that it was a good insulator. The first wires insulated with gutta-percha were laid in London in cast-iron pipes in the year 1849.

Conductors. The chief conductor nowadays is the copper-wire strand or rope. The separate strands which form this rope are usually tinned in order to keep their surfaces clean, because tarnished copper is not so good a conductor as clean copper. The most commonly used moisture-resisting insulators now in use are indiarubber, bitumen, and gutta-percha, and the principal moisture-absorbing, jute and paper. The indiarubber insulation is laid on in two kinds. The first kind, which touches the copper strand, is pure and free from sulphur, because sulphur tarnishes metals. The second kind is a compounded rubber containing sulphur. This will vulcanise and become firm and resilient. The bitumen is first thoroughly refined and then mixed with sulphur and other chemicals, and vulcanised like the second layer of rubber. Before the bitumen is applied, a layer of thin rubber-coated cotton tape or paper is wound round the strand to prevent the sulphur in the bitumen tarnishing the copper. Gutta-percha is used in a flexible state chiefly for low-pressure work, such as telegraphic insulations.

The paper used for insulating purposes is strong manilla paper soaked in resinous compound. The jute is usually applied in the form of a braid impregnated with oily compound.

So far, mention has been made only of the two essentials in a cable—namely, the conductor and the insulation; but it is not often that one meets with a cable in use made only of these two. Nearly every cable has some extra coverings, either to make the insulation perfectly waterproof, or to give the cable some mechanical protection. Lead sheathing, steel tapes, galvanised iron wires, and jute braid are extensively used for these purposes, as will be shown in the following descriptions of cable-making.

Varieties of Cables. Of the several kinds of electric lighting and power cables made, the most widely used are the "Single," the "Concentric," the "Twin," the "Triple concentric," and the "Three core." The *single* cable [1] consists of a central copper strand, a layer of insulating material, a covering of braid, and a sheathing of protective armouring.



1. STRAND CABLE

The process of making a "single" indiarubber insulated cable begins with the conductor. The copper wire for this purpose has usually a tin coating, and comes from the makers, when not drawn at the cable works, in hanks. These hanks are sorted into the various sizes of wire, and the desired size for the cable about to be made is chosen, and thoroughly cleaned to remove all traces of tarnish, dirt, and grease. After being cleaned and examined, single lengths of the copper wire are wound on separate small metal drums or bobbins, which fit round the circular frame of the stranding machine. The number of drums used at one time, and the size of wire wound upon them, depend upon the amount of current the finished cable will have to conduct. A large number, of a large size, are required for a large current. When the drums are in position there is passed through the centre of the machine a central wire to which the ends of all the

wires on the small drums are attached. As this central wire is drawn along the machine is set in motion and the frame containing the drums rotates in such a manner that it twists or strands all the other wires round the central one, so as to convert them into a wire rope or strand [see page 5175].

Applying the Insulator. If the conductor is free from grit and grease after this operation, it is ready to receive its covering of insulation. For this purpose, if it is a small-sized cable, it is taken to the longitudinal machine, which consists of a long, raised bed, at each end of which there is a pair of grooved rollers. Rolls of narrow indiarubber strip are placed before each pair of rollers, the first lot being pure, and the second one compound indiarubber. As the end of the conductor is brought up to the first pair of rollers, the ends of two strips of pure rubber are placed about it, one on top and one below; so that when it comes out at the back of the grooves the indiarubber strips are pressed round in the form of a complete covering, with a firmly-pressed longitudinal joint at each side. Although this joint is made only by pressure, yet if the surfaces of the edges of the strips are perfectly clean, it is thoroughly sound. On approaching the second rollers, two strips of compound rubber are applied in a similar manner, so that when the conductor finally passes out of the machine, it is completely covered with two layers of indiarubber.

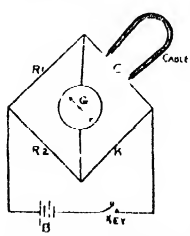
If the cable is of large size, the two kinds of indiarubber are applied by the lapping machine, which covers the conductor by spirally wrapping the indiarubber strips round it instead of pressing them on as at the longitudinal machine. The wrapping of large cables is preferred because the pressure given by the longitudinal machine has not been found satisfactory for the greater thickness of insulation required by them. The separate layers of strips are wrapped in reverse spiral so as to prevent, as far as may be, the possibility of a weak spot in each of two strips, occurring right through the insulation at one place. The thickness of the rubber coating is decided by the considerations of the pressure and disruptive strain that the insulation will have to withstand.

The Indiarubber Covering. When the requisite thickness of indiarubber has been applied, the cable is given a wrapping of indiarubber-covered cotton tape, at the taping machine. This is to add firmness to the covering of indiarubber, which, up to this time, is a plastic substance, of the consistency of stiff dough. In this state it can be easily moulded into any desired shape, and will stick in the shape it is formed. This, of course, is very convenient while the indiarubber is being pressed or wrapped on the conductor, but before the armouring materials are applied over the insulation, it is necessary that it should be firmer and more resilient. With the object of giving these properties to the substance it is taken to the vulcanising house. This is a room containing large, hollow, cylindrical, iron pans to which the necessary pipes, taps, valves, etc., are attached, so that steam may be let in or out as desired. In this room the cable is placed inside one of the pans, after being wound on the drum made especially for the purpose. The pan is closed up by a steam-tight door, and the steam turned on until a certain pressure is reached. This pressure is kept up for a certain time, until the indiarubber is properly vulcanised. The pressure and time of vulcanisation depend upon the quality and thickness of the rubber applied. When the steam in the pan has been let off, and the cable taken out and cooled, it will be found that the outer layer of indiarubber has acquired the desired properties of firmness and resiliency. The acquisition of these properties is chiefly due to the indiarubber containing as one of its ingredients sulphur, which is a vulcanising agent, and which, under the action of steam pressure, chemically combines with the other ingredients and gives the springiness so characteristic of all indiarubber goods. The full chemical action which takes place is not thoroughly understood even in indiarubber manufactures. During the whole process of applying and vulcanising the rubber great care is taken that the surface is quite clean and free from grease of any kind, as the successful manufacture of vulcanised indiarubber cables greatly depends upon the careful handling of the indiarubber.

The cable is now completed as far as its essentials are concerned—it has its conductor and its finished insulation; therefore, before any further coverings are added, either for protection against dampness or mechanical injury, it is taken to the test-house to be tested. Here the cable undergoes a rough test under water, to see that its insulation is sound. A second and more careful test is given when the cable is complete, details of which process will be given later.

Braiding the Cable. If, after the rough test, the insulation is found satisfactory, the cable is allowed to dry, and is then taken to the braiding machine to be covered with a stout jute braid. This braid is moisture-absorbing, and in order to prevent it from rotting, it must be protected from damp. For this purpose the cable covered with braid is passed through the serving tanks, which contain a hot compound, composed chiefly of paraffin wax, and similar substances. The coating of compound on the braid as it comes out of the tanks, besides being damp resisting, is also an insulator, and therefore adds a little to the better insulation of the finished cable. Since indiarubber is a waterproof material, it is not necessary to cover the cable with a lead sheathing, although one is sometimes put on for mechanical protection. The more common method of protecting indiarubber insulated cables against mechanical injury is by encasing them with galvanised iron wires or steel tapes. The wires are stranded over the jute braid by the stranding machine, and the steel tapes are wrapped on by the steel taping machine. Although the iron wires are galvanised as a protection against rust, yet a jute braiding is often applied on the outside of them as a further safeguard.

Testing the Cable. The cable is now ready for its final test, and for this purpose it is taken to the test-house, placed in tanks of water, and allowed to remain there for about twenty-four hours. The testing operation is very important, and takes a day or two to complete. The chief tests made by the makers are those of the conductor, the insulation resistance, and the capacity of the cable.



2. DIAGRAM SHOWING CABLE TESTING

The test of the conductor is usually made by comparing its resistance with that of a known resistance. The comparison may be rapidly made by an instrument known as the Wheatstone bridge [see also page 791]. A simplified diagram of the connections for the comparison is shown in 2.

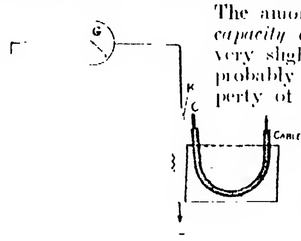
The proportion of the resistance through R1 and R2 is the same as that through C and K when the current passing round the arms causes no deflection in the galvanometer G. R1 and R2 may be read off the bridge scale, and K is a known resistance: therefore the resistance of the conductor under test is easily found from the formula

$$\frac{R1}{R2} = \frac{C}{K} \text{ or } \frac{R1}{R2} K = C.$$

Suppose the proportion of R1 and R2 is 2 1, and the known resistance equals 5 units; then from the second formula the cable will have a resistance of 2×5, or 10 units. Another method of testing the conductor is by the metre bridge, the principle of which is somewhat similar.

The Water Test. The test for the insulation is made after the cable has been in water, at a constant temperature, for twenty-four hours. With the cable still in water, the insulation resistance is tested by a method of comparison. The leakage current through the insulation is compared, by means of a galvanometer, with the flow of current through a known high resistance, when the same battery power is applied. The galvanometer is an *instrument* in which there is a sensitive needle, placed over a graduated circular scale, and surrounded by a coil of wire. This is its simplest form.

As the current passes through the galvanometer, the needle is deflected through a certain angle. The comparison, in its simplest form, is made thus Suppose a circuit is made up of a battery, a galvanometer, and a length of wire. After the current has passed round the circuit for a short time the galvanometer needle will remain stationary at certain deflection from its original position. If the wire is now taken out, and another one of equal length, but of different substance, put in its place, the galvanometer needle, when the current is next sent round the circuit, will come to rest at a deflection different from the one in the first instance. In both these circuits the battery, the galvanometer, and the length of the wire are the same; the only difference is the substance of the wires, therefore any change in the current can be due only to this alteration. Now the current in a circuit is approximately equal to the electromotive force sent out by the battery, divided by the resistance offered to this force by the wires or other substances in the circuit. If the electromotive force is represented by E, the resistance by R, and the current by C, then $C = \frac{E}{R}$. Applying this formula to both instances above, we see that E is the same in both, but C, as shown by the deflection of the needle, is different; therefore the resistance must have altered in inverse proportion to the current. A numerical example will make this clear. Suppose the battery sends out a force of 6 units and gives a deflection, in the first instance, of, say, 30°, and in the second of 20°. Then since the current is proportional to the deflection, we may take it that the first current equals 3 units, and the second 2, and from the formula $C = \frac{E}{R}$ we get, first, $3 = \frac{6}{R}$, and second, $2 = \frac{6}{R}$. Therefore the first resistance equals 2 units, and the second 3 units. Thus the second wire has a resistance of one and a half times the first one.



3. CONNECTIONS FOR INSULATION TESTING

Insulation Resistance Test. In the actual testing of cables the resistance which the insulation should offer when sound is first calculated, and the circuit is made up of a powerful battery, a galvanometer, and a known high resistance, which is approximately equal to what the calculation gives. Figure **3** shows a diagram of connections for insulation resistance testing. A deflection is obtained with the known resistance in circuit by pressing the key K into contact with R. The known resistance is disconnected, and one pole of the battery is connected through the galvanometer to one end of the cable by pressing the key to the right to make contact with C. The other end of the cable is left entirely free, not even allowed to touch the sides of the tank in which the body of the cable lies. The other pole of the battery is connected to earth at E. To complete the circuit, the electricity will have to flow from the battery through the galvanometer into the cable, through the insulation into the water, down the sides of the tank to earth, and along the earth to the wire earthed at E. Thus it will be noticed that the electricity will have to go *through* the insulation as it had to go *through* the known high resistance, and since these are, approximately, equal, the deflection obtained when the cable is in circuit should be nearly the same as that when the known resistance was in. This will be the case when the cable's insulation is sound, and when the ends, which are never allowed to touch the water, are painted with paraffin wax to prevent surface leakage.

A point may be mentioned with regard to reading the galvanometer deflection when the cable is in circuit. When the electricity enters the instrument, a deflection will be shown, but as the electricity continues to flow the deflection will gradually decrease for a few minutes, and then remain stationary. This slow decrease is due to the electrification of the cable; that is, the absorption by the cable of a certain quantity of electricity into itself. The amount of absorption is known as the *capacity* of the cable. If the decrease is very slight, or proceeds unsteadily, there is probably a defect in the cable. This property of electrification may be used as a further test for the soundness of the cable in this way. If after electrification the cable is connected to earth through the galvanometer after the battery has been removed, the deflection of the galvanometer will show that a steadily decreasing current is flowing from the cable. If the deflection decreases at the same rate as when the battery was first put on, the cable is sound.

Testing Capacity. The capacity of the cable may be tested by comparing it with a condenser of known capacity. The condenser is first charged by a battery, and then the accumulated charge is sent through a galvanometer. The cable is first connected to earth to remove all residual charge, and then electricity is sent through it until it has absorbed to its full capacity. This point is reached when the galvanometer needle remains steady. The battery is removed, and the cable connected to earth through the galvanometer, and the deflection compared with that obtained from the condenser. The capacities are roughly in proportion to the deflections.

Continued

INDIA AND AUSTRALIA

Clive and the Battle of Plassey. The Famous Trial of Warren Hastings. The Indian Mutiny and the Tragedy of Cawnpore. Australia To-day

By JUSTIN McCARTHY

THE formation of the East India Company, in 1591, was of great importance in England's relations with Hindustan. The beginning of this enterprise consisted of only three ships, of which but one reached India. The captain of that ship had much trouble with his crew, but he brought back such good news of the prospects in India that a private mercantile company was started, and obtained its first charter in 1600. Its stock valued £72,000, and its fleet consisted of four ships. This was called the London Company, and its charter was renewed by successive enactments. There was a magnificent opening in India for commercial enterprise, because of its vast wealth and varied resources. In September, 1698, a rival company was started called the English Company, and the two companies were afterwards united, and became that East India Company which exercised so important an influence in the condition of India and the financial affairs of England.

India Divided into States. The Portuguese had in the beginning of the sixteenth century made a settlement in India for trading purposes, and the Dutch were also early in establishing an East India Company. They came a little later than the English, while the French East India Company was not established for more than a century after. Soon the whole world of adventure began to send out its fleets to India. India was divided into several empires and states, between which were frequent internecine wars. Dynasties established far back in history were now and then overthrown by a new movement among its own people, or by invasion by some outlying race, and the condition of the country offered continual opportunities to European speculators and adventurers, who sometimes took possession of whole territories. Bombay had been annexed to Portugal, and when Catherine of Braganza became the wife of Charles II., Bombay was ceded to England as part of her dowry. Madras was colonised by the English in 1640, and was afterwards made a presidency under an English governor. Calcutta, which had been a subordinate part of Madras, was created a separate presidency in 1701. There were many disturbances between the natives and the European settlers, and between the European occupants of different territories; wars between the English and the French, and continual rivalry between the Dutch, Portuguese and Spanish, and the later European settlers. New native dynasties were founded on the ruins of native sovereignties, and the different faiths of the people led to many internal revolutions.

Throughout a great part of India a system prevailed which allowed each village to manage, to a certain extent, its local affairs, under the control of the Imperial power, and if the state of which it was a part passed under the rule of a new sovereign or of an invader, the village accepted the new rule, and still managed its local affairs. Owing to this system the settlements of foreign invaders passed in many cases harmlessly over the heads of many of these village populations, and the invader was not likely to encounter much resistance from them.

Dupleix and India. At the opening of the eighteenth century the French were the great rivals of the English in the struggle for the possession of territory and supremacy throughout India. One of the most celebrated men of this time was Joseph François Dupleix, a Frenchman who had early in life been made a member of the French East India Council, and was, in 1741, appointed Governor-General of the French possessions in India. Dupleix showed such marvellous skill in his dealings with the native princes of that region that they entered into cordial terms with the French, and seemed likely to become willing instruments in the promotion of his policy, which was to found a French empire in India. This brought about a struggle between the French and English, and many battles took place by land and sea.

But among the representatives of England was one man who was too much even for Dupleix. This was Robert Clive, the maker of England's Indian Empire. Clive began his career as a clerk in the East India Company. When he had settled in India he was seized with the ambition to become a soldier, and in due course he distinguished himself in many engagements.

The Black Hole of Calcutta. In 1753 he came back to England, where his military fame had preceded him, and on returning to India two years later he recaptured Calcutta, which had been taken from the English, where some 150 English prisoners had been crammed into the infamous "Black Hole," a prison 18 ft. square, from which only twenty-three came out the next morning alive. Clive also captured some of the French settlements, and on June 23rd won the famous victory of Plassey, in Bengal, over the Hindoos under Surajah Dowlah, in which 68,000 of the enemy were completely conquered by about 1,000 English and some 2,000 sepoys, thus securing the establishment of British power in India.

Clive returned to England a rich man, and entered Parliament as member for Shrewsbury, was raised to an Irish Peerage as Lord Clive, and was created Knight of the Bath; but he had to return to India in 1765, where his presence was indispensable. The affairs of the East India Company had been mismanaged, and were

threatened with collapse. Clive went to Calcutta and devoted all his energies to the reformation of the civil and military services, and soon accomplished a complete reform in both departments, proving himself as great a civil administrator as he had been a military commander. Indeed, the practical working of British administration in India dates from Clive's last visit. In 1767 Clive returned to England, and the rest of his story is all sadness. His reforms during his later years in India had made him many enemies; he was attacked by Parliament, and his government of India was made the subject of inquiry by a Select Parliamentary Committee, which ended in something like a vote of censure on Clive, qualified by a few words of praise. Clive felt the reproach thus put upon him most deeply. Some of his actions might have been justly censured, but it is certain that he had made enemies, who put the worst construction on everything he did. He tried to relieve his mental depression by opium, which only increased his melancholy, and on November 22nd, 1774, the great soldier and statesman committed suicide. It is strange that Dupleix, his rival for the mastery of India, also fell upon evil days. He had been recalled from power by the French Government, and he died, neglected and poor, in 1763.

Warren Hastings. The next famous Englishman who took part in the rule of India was Warren Hastings, who was born in 1732 of an old Oxfordshire family. Like Clive, he was compelled by family circumstances to make a living for himself, and in his eighteenth year obtained a place as a writer in the service of the East India Company, and before long became a member of the Council of Calcutta. In 1772 he was made Governor of Bengal and President of the Council, and soon after Governor-General of the British Dominions in India. As Governor-General he had a council of four members, three of whom were sent out from Great Britain. Hastings occupied himself in endeavouring to restore the finances of the Indian Administration, which had been reduced by neglect, bad management, and in some cases by selfish rapacity. He was severe and sweeping in his reforms. Nuncomar, a Brahmin official, being unsuccessful in his intrigues, accused Warren Hasting of peculation. Hastings, in return, had him tried for forgery, of which he was found guilty and sentenced to death. Hastings was accused of unfairness in pressing this charge, and of not having proceeded against Nuncomar in the same manner as against the other officials accused by him. The majority of the Council were opposed to Hastings, and that majority was led by Sir Philip Francis, who is still believed to have been the author of the famous "Letters of Junius," which began to appear in the "Public Advertiser" in January, 1769. In one of the letters, which were a series of attacks on Ministers of the Crown and other public officials, "Junius" said: "I am the depository of my own secret, and it shall perish with me." The enmity between Hastings and Francis had gone so far that they fought a duel, in which Francis was wounded. He retired from office in 1780. Hastings reorganised the revenues, revised the assessments, and greatly improved the administration of justice, and at the same time carried on an almost continual war with the Mahratta tribes, and spread the power of the East India Company more widely. Many of his acts as a ruler were harsh and unjust, and he had little scruple as to the means by which he attained the results at which he aimed. In 1784 he resigned, and returned to England.

A Famous Trial. Not long after this his conduct in office was made the subject of one of the most celebrated Parliamentary inquiries ever held in England. William Pitt was then Prime Minister, and the charges were made by Edmund Burke, Charles James Fox, Richard Brinsley Sheridan, and other members of the Opposition. Hastings was impeached at the Bar of the House of Lords, and his formal trial began in Westminster Hall on February 13th, 1788. The trial lasted more than seven years, for the sittings of the House of Lords were not continuous, like those of a court of justice. On April 23rd, 1795, Warren Hastings was acquitted by a majority of some of the charges, and acquitted unanimously of all the accusations that affected his personal honour and character. But the public in general were certainly not unanimous in his acquittal, and the subject is still a matter of controversy. He was probably too severely judged by the leaders of one party, and too readily exonerated by the other. The principle that a British ruler in India, having many special difficulties to contend against, was justified in adopting any course which helped him to maintain English rule was that against which Edmund Burke declaimed in some of his most eloquent speeches. Sheridan's famous "Begum speech," "relative to the Begum Princesses of Oude," was delivered during the impeachment.

Warren Hastings spent the rest of his days in England, living the life of a country gentleman. Most of his large fortune had been spent on his defence in his trial, but the East India Company made a liberal provision for his closing years. He had numberless admirers throughout the country. He was made Privy Councillor by the Prince Regent in 1814, and four years later his long and eventful life ended.

The Indian Mutiny. In 1784 Pitt had passed a measure establishing a Board of Control to assist, and, when necessary, to overrule the Executive Government of India and the East India Company. The president was to be a leading Minister of the Crown, and a member of the Cabinet. This lasted until 1858, when the Government of India was transferred to the Crown. The history of India, in the meantime, was a series of wars and conquests, wars against native princes, risings against British power, many checks and disasters to the British forces, but complete success ultimately for British arms, until at last the whole of the great peninsula was under the rule of England.

The most memorable event of this period was the Indian Mutiny, the mutiny in the

Bengal native army, which began in 1857. One of the greatest difficulties at this time was caused by the large number of natives whom the rulers of India had to employ, as it was impossible to provide a large enough army of Englishmen. A number of sepoys who seemed willing to enter the service were therefore employed. Some of these troops were found to be in sympathy with the Indian princes in their struggles against English dominion, but the mutinies which, in consequence, occasionally arose were easily suppressed. But the Mutiny of 1857, which began with incendiary fires at Barrackpur in January, and a mutiny of sepoys in February, was more extensive, and had a more definite object. The 11th and 20th Native Infantry and 3rd Cavalry in the garrison at Meerut, near Delhi, mutinied on May 10th, killed their officers, and marched to Delhi, and were there joined by the native troops, and received with enthusiasm by the native population, who killed the Europeans. The rising was not merely a sepoy revolt or military mutiny, but a sudden combination of mutiny, race hatred, and fanaticism against the dominion of England. The uprising of the native soldiers may have been the signal for the outbreak of that religious and political storm which had long been gathering.

The Cause of the Outbreak. The native princes and soldiers acted together, while the Mohammedans and the Hindoos suppressed for the time their own religious differences and united against the Christians. It was at first believed in England that the revolt was caused by the distribution of the Enfield rifles, the cartridges being wrapped in paper greased with cow's fat or hog's lard. This would have been to the Hindoos a profanation of the cow, which they venerated, and to the Mohammedan it was pollution to touch any product of the pig, which he regards as an unclean animal. The Government made every effort to assure the native soldiers that the cartridges were not so greased, and that nothing had been done to offend their religious feelings or caste sentiments. But if the alarm about the greased cartridges had not set the mutiny alight, some other cause would undoubtedly have done so. The mutineers in Delhi claimed the protection of the descendant of the great Timur, the King of Delhi, as he was still called. He was a man of over eighty, who had long been a pensioner of the East India Company, and it had been arranged that the title of King should die with him. The mutineers proclaimed him Emperor of India and leader of their revolt. Thus the mutiny became an uprising.

Lord Canning and the Mutiny. There had been a prophecy well known throughout India that the hundredth anniversary of the Battle of Plassey would see the end of England's dominion, and at the time that it was being celebrated in England the mutiny was in full movement. Lord Canning, the third son of the famous George Canning, was then Governor-General of India. He had succeeded to the title on the death of his mother, on whom it had been conferred after her husband's death. He held office for some years in England, and in 1856 he succeeded Lord Dalhousie in India. Though he had been there such a short time before the mutiny broke out, he proved equal to the occasion, and in that period of commotion he remained resolute and calm.

The Tragedy at Cawnpore. Lord Canning considered that the first thing to be done was to recapture Delhi, which had become the centre of the rebellion. A large body of English troops on their way to China were summoned to India by him to help in putting down the mutiny, which had broken out at Lucknow, at Cawnpore, and at other places. The tragedy of Cawnpore is one of the most terrible events of the war. It was caused chiefly by the treachery of Nana Sahib, the adopted son of an Indian prince, who professed to be an ally of the English, and was trusted by them, but he had long been plotting against the English Government because he felt aggrieved by Lord Dalhousie's rejection of his petition for the Peishaw's pension. He went over to the mutineers as soon as the mutiny began, became one of its chief instigators, and it was under his leadership the mutiny at Cawnpore broke out on June 5th.

He surrounded the Residency, where the English inhabitants had taken refuge. They were sheltered by entrenchments of a worthless character, but the garrison, diminishing daily in numbers, held out with splendid courage, and prolonged the defence until June 24th, when the ammunition and food were exhausted. The condition of the women and children was terrible, having neither food nor water nor adequate protection from the fire of the mutineers. But the sepoys showed themselves unwilling to approach too close to the fire of the indomitable British soldiers. Nana Sahib saw that he could not take the Residency by assault, and he could not wait until the garrison had died of hunger as he feared some large body of soldiers might come to their relief. He therefore offered to transfer all those who would surrender in safety to Allahabad, and to supply them with food in the meantime. The English, seeing no other chance of safety, accepted his terms.

The Treachery of Nana Sahib. The evacuation of the garrison took place on June 27th. The women and children were helped into the boats, and the officers and men were about to follow, when the sound of a bugle was heard—a signal from Nana Sahib—and the native rowers set fire to the straw roofs of the boats, from which they themselves escaped. At the same moment shots were fired from both banks of the river at the blazing boats. This deadly fire lasted until the greater number of the passengers had been shot, and the survivors were brought back to Cawnpore. Nearly all the men captured by the natives were immediately shot, but 112 women and children were imprisoned in a small house near Cawnpore. Some of the women were compelled to grind corn for their gaolers, but it seems that no other indignity was offered them.

After the English victory on July 15th, it was decided that all who remained should be killed, and on the following day they were murdered, some by shot and some by sword, and their bodies thrown into a dry well. There seems to be no

doubt that some were still alive at the time. Sir Henry Havelock fought his way into Cawnpore, but only in time to see the horrible evidences of the massacre. The well was filled up after the bodies had been buried, and a memorial chapel raised on the spot. Nana Sahib made his last stand against the English near Cawnpore, and was completely defeated. He managed to escape, however, and nothing was known of him after. Leaving Neill at Cawnpore, Havelock marched on Lucknow. He was afterwards reinforced by Sir James Outram. On September 10th Brigadier Greathed surprised and routed the mutinous troops from Rajpootana and Agra. Sir Colin Campbell, afterwards Lord Clyde, effected the final relief of Lucknow in November 1857. The capture of Delhi was accomplished in September of the same year.

A young English officer, William Steven Hobson, who formed the body of cavalry known as "Hobson's Horse," offered to capture the King of Delhi and his family, and was permitted to do so by General Wilson, on the condition that he spared the life of the king. He found the Royal Family surrounded by armed men, but his manner convinced them that he had a large force within call, and they surrendered. Hobson spared the life of the king, according to his promise, but regarded the three princes as rebels, and, taking a carbine from one of his troopers, he shot them dead.

The End of the Mutiny. By the end of 1857 the revolt in Bengal had been nearly suppressed, and in many other parts of India order had been restored. At the beginning of the following year the last of the Moguls was transported to Burmah. During January and February Sir Colin Campbell succeeded in clearing Oude and Rohilkhund, and in March went to Lucknow, and at last wrested the city from the enemy. Meanwhile, Sir Hugh Rose, commanding the Bombay division, advanced to the relief of Saugor, and defeated the rebels at Muddunpore. In April he defeated Tantia Topee, and took the fort of Jhansi, and in May the fort of Kalpy. In June he again defeated the rebels outside Gualior, and captured the city. Napier defeated the rebels at Alipore, and this ended the campaign.

It was found that the cost of suppressing the mutiny was not less than £40,000,000. When order was restored, the proportion of native troops was much reduced, the artillery being mainly composed of English gunners. On September 1st, 1858, the Government of the East India Company came to an end, and on November 1st Queen Victoria was proclaimed Sovereign throughout India, with Lord Canning as her first Viceroy.

AUSTRALIA

One of the most important parts of England's Empire is that made up of the Australian Colonies. It was not until 1686 that Englishmen landed on the great island. William Dampier landed there in 1686, and Captain Cook, the famous navigator, in 1770; and with him really begins England's ownership of Australia. England sent before long a stream of emigration to the new soil. The whole of the Australian continent became a recognised part of England's dominions. The name Australia was only given to the island when English influence began to prevail, for it had been named New Holland, while the Dutch claimed to have been its earliest discoverers.

For a long time—indeed, down to recent days—some of the Australasian Colonies were used by England as places to which convicts from these islands could be transported and held in penal servitude. Nor was this sentence inflicted only on criminals convicted of gross crimes, but upon men of the highest character and honour who had taken part in Ireland's rebellions—men like Smith O'Brien and John Mitchel. The Colonies might have made less complaint if such men as these were the only convicts sent into Australia by British law; but it became intolerable to the Australians, after a while, that their soil should be used as a place of imprisonment for men whose presence England would not endure even within her prisons. The system was gradually relaxed, and came to an end in 1857.

Discovery of Gold. In 1851 gold was discovered in New South Wales, and soon after in Victoria and other parts of Australia, and there was a sudden rush of immigration from Europe and many other parts of the world into the gold-producing regions. The population of Australia has been steadily growing during recent years, and prospering with its growth.

The Government in England acted with a wise liberality towards the Australian colonists in allowing them as far as possible the management of their own affairs, and no such crisis has been provoked as that which once brought the people of Canada into actual rebellion.

The different Colonies of Australia have been for the most part on friendly terms with each other, and the principle of local self-government has been proving itself more and more effectually as time went on. The Australian Colonies on more than one occasion showed their loyalty to the British Crown by giving their assistance to England in some of her foreign wars. At length a scheme of colonial federation was formed, by virtue of which the Australian Colonies became associated in one federal system with the sovereign of England at its head, each Colony managing its own local affairs for itself, and the interests of the whole continent being under the care of what may be described as the federal government. Each Colony has a Legislative Council or Senate, and a Legislative Assembly corresponding in its arrangements to our House of Commons. The Legislative Assembly is elected by manhood suffrage, or by voters whose qualification, so far as property is concerned, it is not difficult to obtain; and all votes are taken by ballot. The Bill for the founding of the Australian Federation was finally passed by the Imperial Parliament in 1900, and came into force on January 1st, 1901.

Continued

TEA, COFFEE, AND COCOA

Cultivating Indian and China Teas. Black and Green Teas. Tannin. Coffee Growing and Manufacture. Chicory. Cocoa and Chocolate. Soluble Cocoas

By CLAYTON BEADLE and HENRY P. STEVENS

TEA is an infusion of the prepared leaves of the tea plant, the species usually employed being the *Thea chinensis* and *Thea assamica*. It was first met with in China, where it is said to have been used four centuries B.C. It was, however, a very common article in the eighth century A.D. Its introduction to Europe dates from the beginning of the seventeenth century, and the import into this country had grown into considerable magnitude by the middle of the eighteenth century, when it became quite a general beverage.

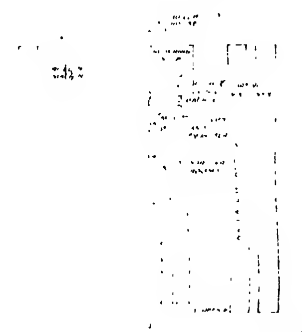
The tea plant is a native of China, and was introduced into India in 1850, but as now grown in India it is generally a hybrid with Chinese varieties.

Tea, as it is put on the market, may be divided into two classes, the green and black teas. This distinction is based solely on the method of manufacture, and is not due, as originally supposed, to a difference in the tree from which the leaves are derived. Both green and black teas are produced in China, Japan, Assam, and Ceylon, although it is usually admitted that the best green teas are made in China [see also pages 1960 and 1961].

Cultivating the Tea Shrub. The cultivated plant is a bushy shrub, not exceeding 6 ft. in height, and somewhat resembling a Portugal laurel. The leaves should not be plucked when the trees are too young, otherwise, when they come to maturity, the yield is much impaired. The plan usually adopted is to pluck the leaves when the plant is three years old: the yield will then be about 80 lb. of tea per acre. The best yields will be obtained from trees which are six or seven years old, when the yield will amount to 320 lb. per acre, although maximum yields, amounting to 800 lb., have been obtained in India. After the eighth year it is preferable to replant. The seeds are usually gathered in October, about a year after the flower has faded, and are then kept in sand and earth until the following March. By this time the will have germinated, and are ready for planting out. Old trees are removed every year and replaced by seedlings. In selecting the ground, attention should be given to thorough drainage and irrigation, for which purpose a good supply of water is necessary. In general, hilly districts are best adapted for the purpose, and the soil should be a rich loam.

Gathering the Crops. Whether for green or black tea, the leaves are plucked three or four times a year, those first plucked producing the best tea. The crops are classed according to the age of the leaf, and designated according to their source. Some of the more important are Hyson, Pekoe, Souchong and Congou. Hyson is a term applied in China to the leaf-buds and the first leaves picked in April and made into green tea. Other green varieties are known as "gunpowder," Tankay, and Imperial. Of the black varieties, Pekoe represents the youngest leaf and leaf buds gathered in April. Sometimes it is flavoured by the addition of orange and other flowers, when it goes by the name of "Orange Pekoe." The same term is applied in Assam as in China. The term "Flowery Pekoe" is also applied to this class. Souchong is plucked next, and is followed by Congou.

Chinese Methods. The manufacture of green tea differs from that of black tea in that it is prepared as quickly as possible from the freshly-plucked leaves, without allowing any fermenting processes to set in. On the other hand, with black tea a certain amount of fermentation is encouraged. The processes employed vary somewhat in different countries, but in the case of green tea they do not differ so much. The leaves gathered in the morning are treated the same day. The first process consists in steaming, with subsequent drying, although in India the steaming process is usually omitted. When dry, the leaves are roasted—that is to say, they are heated in pans over the fire, stirring continuously. The temperature should not rise above 160° F., and the process lasts about five to seven minutes. The leaves, now in a soft, pulpy state, are rolled to break the cells and liberate the aroma; the rolling operation is followed by drying in the sun; and these processes are repeated three times in succession, and then followed by another roasting, after which they are sifted and sorted, and finally roasted again, although the order of the last two operations may be reversed.



1. PLAN OF INDIAN TEA-HOUSE

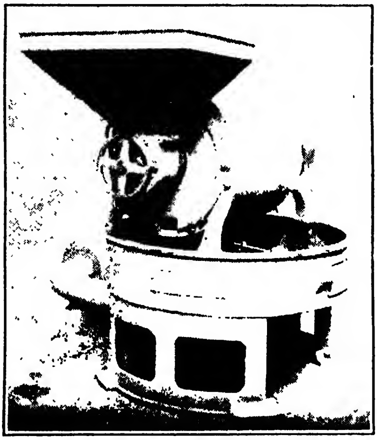
In the case of black tea, after drying in the sun and rolling, which may be accomplished either by hand or in the rolling machine, the leaves, in the form of balls, are left to ferment. This process must be put an end to at the right moment in order to obtain the best result, and it is effected by breaking up the balls and spreading the leaves in the sun to dry. This is followed by firing, the leaves being spread on trays with gauze bottoms, heated from underneath by fire. After hot firing, the leaves are ready for the market.

Tea Cultivation in India and Ceylon. As by far the greater proportion of tea imported into this country comes from India and Ceylon, we shall describe the methods there employed for cultivation and manufacture.

In March the young shoot, with fresh leaves, or the first "flush," is ready for gathering. This consists of a shoot or new growth bearing the bud and five or six leaves. The pluckers gather the bud with one, two, or three leaves, according to the quantity desired. The buds yield the finest tea, known as "golden or silver tip." The top leaf

produces Orange Pekoe, or, when large, " Pekoe." The second or lower leaf also yields Pekoe, but, when large, Pekoe Souchong (Christison).

The pluckers go round the gardens at intervals of about a week. It is very important that they should avoid gathering leaves which are too coarse, or unripe shoots. The baskets with the leaves are returned as quickly as possible to the tea-house.



2. COCOA-ROASTING MACHINE

Manufacturing Operations. These are as follows [see illustration 1, showing plan of an Indian tea-house]: (1) Withering or limping; (2) rolling or curling; (3) drying or firing; (4) separating or sorting and cutting or equalising; (5) final firing; (6) packing for export. These operations take together some 22 hours to 26 hours. The withering is carried out in houses built open at the sides, fitted with layers of trays or racks. The object of withering is to remove 20 per cent. to 50 per cent. of the water, so that when subjected to the next operation, the rolling, the leaf is sufficiently tenacious to stand this somewhat rough treatment. The leaves are now taken to the rolling machines. These are of special construction, and give to the leaves the necessary twist, at the same time rolling them into balls. The balls are then broken down.

The next process consists in spreading out the withered leaves on the concrete floor of a large chamber. The chamber is kept dark, and the leaves are covered with cloth or muslin saturated with cold water. In the course of from two to eight hours the so-called fermentation process is complete.

They then pass to cooling and oxidising machines, in which they are spread out on wire-gauze covered tables, through which a current of air is drawn.

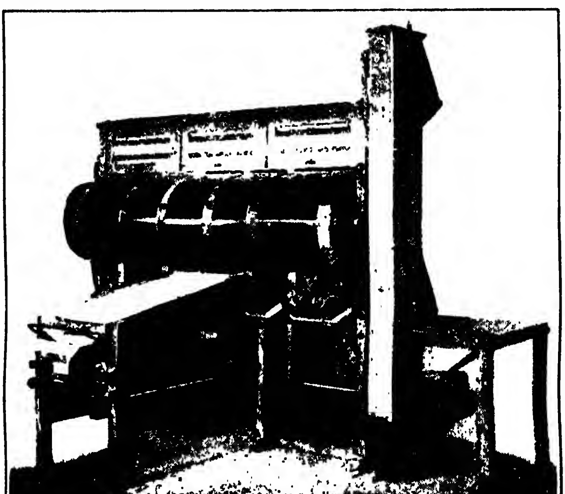
Methods of Firing. They are now taken to the tea drying and firing machines. In large factories this is best accomplished in three stages. In the first stage the leaf is passed quickly through an automatic machine which immediately checks the fermentation by exposing the leaves to a temperature of 300° F. The effect of this is to turn them darker in colour, and they leave the machine half dried. The second is a similar automatic drying machine, the temperature of which is 200° F., and on leaving this machine the leaves are almost dry. The third stage is accomplished in a machine under control, so that the operation may be carefully watched. The object of the process is to drive off the moisture as completely as possible without losing the essential oils.

The roasted leaves are next picked over by hand and then passed through a mechanical sorting machine to remove foreign matter, stones, dust, etc. The leaves then pass to circular or revolving sieves fitted with wire of different mesh, so as to separate the leaves into two or three qualities. The general principle of the machine is similar to one which has been already described [see MILLING, page 3079]. The different products are now subjected to a final firing to remove any residue of moisture, after which they are ready for packing.

Chemistry of Tea. The aroma of tea is due to small quantities of volatile oil not exceeding ½ per cent. of the weight of the tea. The peculiar physiological action is due to a substance formerly termed "theine," but now generally known as "caffeine," as it has been found to be identical with the alkaloid obtained from coffee. Teas also contain a considerable quantity of tannin, averaging from 10 per cent. to 20 per cent. The public analyst is not often called upon to examine teas, as all that is imported into this country is examined by the Customs authorities, and rejected if found to be adulterated.

CONSTITUENTS OF TEA-LEAVES

Constituents.	Original leaves dried.	Same made into green.	Same made into black.
Crude proteins ..	37·33	37·43	38·30
Crude fibre ..	10·44	10·06	10·07
Theine (caffeine) ..	3·304	3·200	3·300
Tannin	12·91	10 64	4·89
Hot-water extract	50·97	53·74	47·23
Ash	4·97	4·92	4·93



3. COCOA-NIBBING, HUSKING, WINNOWING AND GERM-EXTRACTING MACHINE

The proportions of essential oil, caffeine, and tannin vary considerably, and there is also a distinction between the quantities in green and black teas.

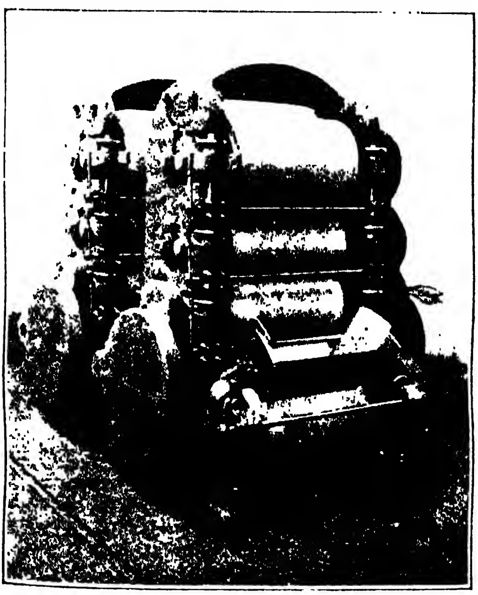
A great number of analyses have been made on tea by different authorities. The table given above, obtained by a Japanese chemist, will give some idea of the effect of constituents on the original leaves when converted into green and black tea.

In the above figures it will be seen that the constituent most affected by the process of manufacture

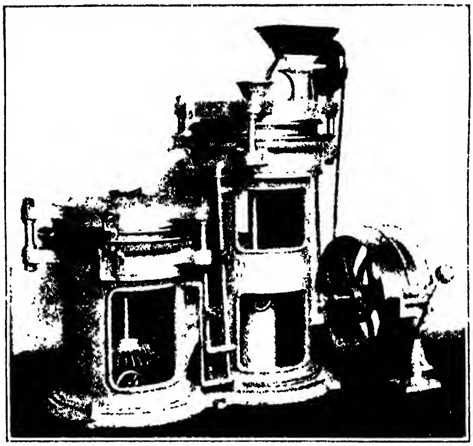
is tannin, of which the green tea contains more than twice as much as the black, from the same leaves [see also page 3378].

Coffee. Coffee consists of the roasted seed contained in the fruit of the coffee tree (*Caffea arabica*). A number of species and varieties have been discovered, three of which are now cultivated: (1) The Arabian or Mocha coffee, which differs from the others in that it usually contains only one seed in each berry; (2) Jamaica coffee, which has usually two seeds in the berry: and (3) East India or Bengal coffee, characterised by its small berries. The cultivated plant is usually about 6 ft. high, and would grow much higher, but its height is kept down by pruning. It is grown in various parts of the world, generally at some height above the sea-level. It is cultivated in the West Indies, Mexico and Central America, Brazil and various parts of Africa, Arabia, India, Ceylon, and parts of the East Indies, but it is chiefly grown in Brazil. The fruit has been likened to a small black cherry and consists of sweet pulpy matter surrounding one or two seeds, which seeds are themselves enclosed in a thin tough membrane termed the parchment.

Manufacturing Operations.. The fruit is allowed to ferment to help the removal of the outer pulp, and the parchment is got rid of by passing the seeds between rollers and winnowing out the husk. The bean is yellowish in colour, and has to undergo a process of roasting to fit it for consumption. The roasting effects two objects - it brings about important chemical changes which develop the flavour; and at the same time the raw bean which is tough, is rendered brittle, so that it can be more easily ground. The process of roasting requires care: under-roasted beans yield an infusion with a raw flavour, whereas if too strongly heated they are burnt. Usually some sort of rotary apparatus is adopted by which the beans are kept in motion and uniformly heated [see also Roasting Cocoa]. The temperature should not rise above 450 °F., and the beans should lose about 18 per cent. of their weight when roasted to a chestnut brown colour.



5. CHOCOLATE-REFINING MACHINE



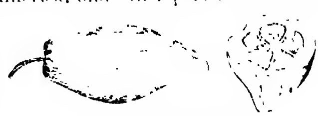
4. COCOA-GRINDING MILL

It is stated that a loss of 20 per cent. means injury to the beans.

Composition and Constituents. The most important constituents of coffee are the volatile oil, to which its fragrance is due, and the alkaloid caffeine which has already been described under Tea. The oil was isolated by Bernheimer from the distillate obtained by heating coffee beans. It is an oil boiling at 195 to 197 C., and has been termed "caffeol."

Coffee is frequently adulterated, and while the substitute generally used is chicory, many other substances have also been employed, including according to Penman and Moor dandelion root, mangel-wurzel, turnips, beans, peas, flour, and condemned sea biscuit more or less caramelised by baking, and burnt sugar. In addition to this, a patent has been taken out for the manufacture of artificial beans from chicory and other adulterants. Anyone familiar with the bean would have no difficulty in detecting the imitation article, although they are not met with much in this country, it being more profitable to adulterate the ready ground coffee. On chemical analysis coffee contains about 1½ per cent. of caffeine, 12 per cent. to 20 per cent. of fat, 30 per cent. to 37 per cent. of cellulose, and about 4 per cent. of ash.

Cocoa. - Cocoa, sometimes spelt "cacao," is made from the seeds of the *Theobroma cacao*, a tree of some size which grows in the West Indies, Brazil, Central America, and other parts. The fruit is elongated in shape and consists of five compartments containing a sweet pulp in which the seeds or beans are embedded [6]. The fruit is split in two and the beans separated from the surrounding pulp and spread out to dry on bamboo floors exposed to the sun. To rid them of a certain amount of adhering pulp, and also to improve the flavour, they are submitted to fermentation. For this purpose they are placed in wooden barrels, covered over with leaves, and left a day or two. The process is complete when the colour has changed from red to chocolate. The beans are then taken and washed to remove the adhering portion of pulp, and after drying are ready for export. The cocoa seeds or



6. CACAO FRUIT

beans are the raw material for the manufacture of chocolate, cocoa, and various sweetmeats.

Manufacturing Chocolate. The manufacture of chocolate comprises the following operations (Zipperer): (1) Storing, cleansing, and sorting; (2) roasting; (3) crushing, shelling, and removing radicles; (4) mixing the different kinds of beans; (5) grinding the beans until they yield a homogeneous pasty mass when warmed; (6) the incorporation of sugar and spices with the liquefied cocoa mass; (7) trituration by rollers; (8) extraction of air and division and moulding; (9) cooling the finished chocolate.

In general chocolate may be defined as a mixture of pure cocoa (free from shell or germ) and sugar, with the addition of cocoa butter, spices, vanilla, or other flavouring as required.

The beans are first cleaned or roughly sifted, so that the dirt and flat beans are separated out. A cocoa-bean cleaning machine may be used, and the clean beans are delivered on to a travelling web, and any stones or foreign substances which have passed the machine, being about the same size or larger than the beans, are picked out by hand.

Roasting Cocoa-beans. The picked beans are next roasted for the purpose of developing the aroma, gelatinising the starch granules, and rendering the husk or shell brittle so that it is more readily removed; at the same time the astringency is largely got rid of. The plant usually employed consists of a roasting drum similar to that used for coffee, but the temperature required is lower, and should not exceed 130° C. to 140° C.

The illustration [2] represents a gas cocoa-roaster. The revolving drum is heated externally, and the gas is mixed with heated air to render the combustion more complete. The beans are fed through the hopper at the end, and the inside of the drum is fitted with helical blades to ensure the beans being turned over and fed constantly to the centre. The heated gases and steam from the beans escape through the hollow shaft of the trunnion of the bearing.

Separation of Husk and Germ. After roasting, the beans are delivered into a cooler below, the bottom of which is provided with a perforated plate so that air can be drawn through the beans by means of a fan. When sufficiently cooled, the beans are treated to separate the husk or shell and germ from the particles of kernel. For this purpose they are crushed, keeping the pieces of shell as large as possible as this facilitates subsequent separation. The cocoa nibbing, husking, winnowing, and germ-extracting machine is shown in 3. At the bottom of the hopper is a "nibber," with two pairs of rollers (seen on the right-hand side of the figure) to crack the beans, which are then taken up by the elevator and delivered into a revolving drum made up of six different sections of perforated metal, each of which is somewhat coarser than the last. Each section is provided with a fan which blows away the particles of shell, leaving the clean cocoa-nibs to fall upon inclined sheets fitted to each section. As a small amount of nib may be carried over with the shell, an intermediate chamber is provided, into which it falls, most of the lighter husk being carried beyond. This chamber is fitted with a worm so that the mixture of nib and shell is returned to the hopper for treatment over again. About the centre of the drum the perforations are of such a size that medium-sized nibs and germ pass through together. They are conducted to inclined sieves and a perforated drum, by means of which the germ is removed much in the same way as cockle is taken out of wheat [see MILLING, page 3080]. Here it is the particles of kernel lodge in the hollows of the walls of the cylinder, while the germ passes off as tailings.

Grinding and Refining Machines. For whatever purpose the cocoa is required it is essential that it should be finely ground. For this purpose the French form of mill, consisting of two stones, a bed-stone and a runner on a vertical axis, is usually employed. The action of this form of mill has been described in PAINTS AND POLISHES [page 5142]. Figure 4 shows a double stone cocoa-grinding mill.

The cocoa, which is fed into the middle, leaves the stones in a semi-liquid condition. The ground cocoa is not heated until it is liquid, when it is transferred to a melangeur or to a mixing and kneading machine, where the necessary sugar and spices are added.

The stiff paste is then passed through chocolate refiners. These are built either with inclined rolls or are upright machines with rolls superimposed. Two upright refiners are shown [5] coupled together to form a battery. The refining process reduces the chocolate to a smooth condition; it is then usually stored in blocks for some time in a dry room. Illustrations 2 to 5 are from photographs of machines constructed by Messrs. Joseph Baker & Sons, Ltd.

For conversion into tablets it is mixed or kneaded as required and passed through a weighing machine, which also compresses it and extracts any air, and thence to moulds. For certain kinds of chocolate, especially if larger quantities of sugar are added, an addition of cocoa butter is made; but for some cheap ordinary chocolate this is replaced by a cheaper vegetable butter such as coco-nut fat, and the outer shell or husk of the bean, representing 20 per cent. by weight of the whole, is also ground up and utilised. Milk chocolate contains a large proportion of con centrated milk, and a smaller proportion of cocoa.

Cocoa Powder. For use as the beverage commonly known as cocoa or "soluble" cocoa, the preliminary processes are carried out as we have already described: but at some stage the material is treated with weak alkalies, such as carbonate of soda, potash, or ammonia, and heated, the effect of which is to modify the cellular matter or saponify part of the cocoa butter in such a manner that, on mixing with hot water, the cocoa remains suspended instead of settling at once (so-called Dutch process).

Some English manufacturers, however, do not use alkali and yet are able to obtain a cocoa quite as soluble as with the Dutch process, but perhaps somewhat lighter in colour, the effect of the alkali being to darken the cocoa when in the cup. French makers are not allowed to use alkali. It is also necessary to remove a large proportion of the oily or fatty matter contained in cocoa—namely, the cocoa butter. This is carried out after roasting by hydraulic presses. Altogether the cocoa butter forms about half the weight of the seed. It is a white solid fat which melts at the low temperature of 30° C., a little below the normal temperature of the body.

Cocoa contains an alkaloid, theobromine, which is a characteristic and important constituent. It is chemically closely allied to caffeine, but its physiological action is stronger.

The amount of theobromine is usually about $1\frac{1}{2}$ per cent.

FOOD SUPPLY *concluded*

INDUSTRIAL USES OF PAPER

The Manufacture of Envelopes, and of Paper Bags and Boxes. Cellulose and Artificial Silk

PAPER-MAKING continued from page 6401

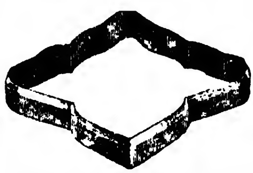
By CLAYTON BEADLE & HENRY P. STEVENS

ENVELOPE MANUFACTURE

Envelopes first came into general use with the introduction of the penny prepaid postage system in or about the year 1840. Prior to this period the written documents were folded and sealed, but with the introduction of the aforementioned prepaid postage system this method was found unsuitable and inadequate, and the envelope was invented and brought into general use. At this time envelopes were made by hand throughout, but as the demand increased, machinery was brought into use, and very few envelopes now are made by hand, only the very best envelopes, and those of an unusual size, being made in this way. Envelope manufacture by machinery may be classified under three headings—namely, cutting or punching, gumming of the sealing flap, and folding.

Punching or Cutting. For this a cutter or die [45] is used of the shape or outline of the envelope when it is in the "blank"—that is before it is folded. This cutter is made of the best steel, and is usually 1¾ in. to 2¼ in. deep. The paper out of which the envelopes are cut is placed in a pile of suitable height on the bed or lower platen of a specially constructed machine known as a punching or envelope cutting machine [46]. The cutter is then placed upon the paper, and the top platen is clamped down on to the cutter; this sets the driving gear into motion, and the cut takes place, the top platen is released, automatically opened, and the machine stopped, ready for placing the cutter in position for the next cut, the entire operation occupying but three seconds.

Gumming of Sealing Flaps. The blanks are then taken to the gumming machine [47] for gumming the top or "sealing" flap of the envelopes. A pile of blanks (about 4 in. high for thin paper, and 6 in. high for thick qualities) is placed on the feeding table of the machine. The blanks are then carried round a drum, being held in position by means of tape under the gummer, thence over the drying plates, under which gas jets are burning, and are delivered on the collecting table at the other end of the machine. The pressure of the gas can be adjusted according to the thickness and quality of paper used. This machine will automatically gum, dry, and deliver envelopes at the rate of 20,000 per hour at an inclusive cost of less than a farthing per thousand. One of these machines is sufficient to keep six folding machines employed.



45. ENVELOPE CUTTER OR DIE

Folding. The blanks are then taken to the folding machine [48]. The machine as illustrated is the well-known "Reay" machine, as used by the Stationery Department of the General Post Office. With this machine the feeding, creasing, folding, delivering, and collecting of the envelopes are performed with the aid of but one attendant, who has ample time to band the envelopes so produced. The attendant sits down in front of the machine and places in the proper receptacle a number of blanks, the number being regulated by the substance of the paper. The blanks are conveyed singly by pickers (the pickers also gumming the bottom flap of the envelope) to the creasing box. After having been creased, the envelopes are, by a double action of the plungers, securely and correctly fastened at the bottom flap, and folded. After leaving the plungers, they are mechanically collected and delivered to the attendant for banding. From the time the blanks are delivered to the machine till the perfect envelope is turned out, the attendant has nothing to do with them, thus having ample time to band them up. This machine turns out high-class envelopes at the rate of from 2,000 to 3,000 per hour.

"Leader" Envelope Folding and Gumming Machine. This machine [49] completely folds and gums envelopes or bags ranging in size from the well-known small coloured packet which contains garden seeds to the very large official end and side opening envelopes, used for specifications, documents, and the like, at a speed of from 60 to 105 per minute. In a factory where this machine is installed it is imperative that a platen cutting machine is also at work supplying the folding machine with the blanks cut to size out of the flat reams of paper, a steel knife or cutter of the proper shape of the envelope or bag required being used. The blanks, when cut, are passed to the folding machine and placed on the work table in front in a pile about 6 in. high and automatically lifted off, a sheet at a time, as the formed gummer takes them off the pile, and leaves them on the carrying rails to pass underneath the top plunger, which in turn creases them through a convenient sized box with the four side flaps turned up ready for the folders, turning them over and closing same into shape. A hinged platform instantly falls down, which is carried on the main table of machine, and allows the folded envelope to fall through side guides into the drying chain, which, at the proper time, has a pair of its links in an open position to receive the envelope and carry it one space along out of the way of the next one following.

While the machine is at work, and the finished product gathering in front of the attendant, he or she is engaged gathering the bundles of envelopes, —which are counted into 25's by a counter on the machine—and placing the band round, the packets being then laid in a box ready for the packing-room.

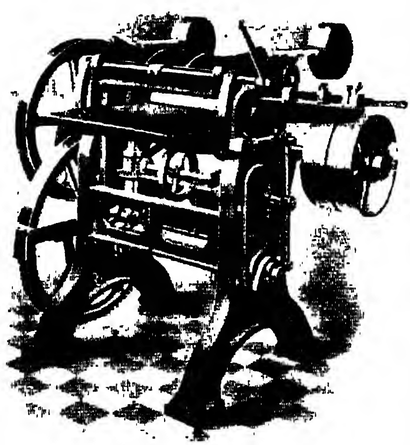
PAPER BAGS

The manufacture of paper bags has during the past fifty years developed into a considerable industry. Hand-made bags still survive, but in lessening proportion to the ever-increasing bulk of the machine-made bag. Paper bags, whether hand or machine-made, divide as to form into three main classes: (*a*) The "plain" or "flat" bag, made like a wheat sack without attempt to prepare the bottom for squaring or flattening; (*b*) the "square,"

otherwise "block-bottom" bag, with its bottom folded so that on filling it with little or no assistance forms itself into a square or oblong square package with a flat bottom (the satchel bag is also in this class); and (c) the "conical bag," that makes no pretensions to standing on end, but is of shape that affords ready access to the fingers.

As regards structural formation, one thickness of paper only is the rule, but all are occasionally made of two thicknesses (lined bags), the outer for strength or display, the inner often of impervious material to retain the aroma of the goods or prevent contents exuding, or to protect the contents from exterior damp. Further, to separate the goods contained from contact with a coarse or highly-printed or coloured wrapper, a clean and tasteful lining is often advantageous.

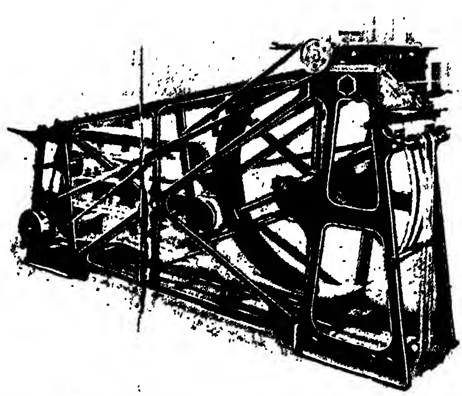
Special Requirements. Hand-made bags are now practically confined to special requirements, such as bags of unusual size, elaborately printed bags, most kinds of lined bags, and bags which must not show certain peculiarities inherent to machine-made bags, or where the quantity ordered is small. To these must be added the output of firms who, by cheap hand labour, struggle to compete with machinery.



46. ENVELOPE CUTTING MACHINE (Joseph Richmond & Co., Ltd.)

Flat "formers" of tin or zinc are used by the hand-workers to fold the sheets of which the bags are made, and in the case of block-bottom bags a hinged flap is sometimes added to assist in making the "diamond" fold of the bottom. In the hand-making of self-opening satchel bags a collapsing "former" is used. In some cases the bags are made partially by machine and partially by hand, the paper being folded and pasted by machine into long, flat tubes, and by it cut into lengths, the bottom being formed on these lengths by hand.

Except when they can be used without packing together for transport, bags, whether machine or hand-made, are always made "on the flat" — that is, the tubular body and the bottom are folded in the same state in which they are subsequently packed and transported in bulk. All kinds of adhesives are used in hand and machine work, wheaten paste predominating, dextrins and gums following next.



47. GUMMING MACHINE (Joseph Richmond & Co., Ltd.)

Continuous & Intermittent Machines. *Paper-bag machines* may be divided into three main types. Class I. comprises *high-speed, continuous action machines*, producing flat, often called plain bags [50], satchel bags (simple style), satchel bags (compound style) in all thickness papers, and oblong block-bottom bags in medium and thick papers; also conical bags (all thicknesses). The speeds of these machines on medium-sized bags range from 120 to 200 per minute, small bags still faster, conical bags one-third slower. These machines always draw their supply of paper from a web of paper of suitable width wound into a roll. The usual maximum size for ordinary bags in this country is about 12 in. wide by 19 in. long, flat make, or its equivalent capacity in other shapes; but in the United States and Canada bags of double this size are met with. Conical bags are seldom used to contain more than ½ lb. of goods. Millinery bags are made up to 22 in. wide and of proportionate length.

Class II. comprises *intermittent action machines*, of the square block-bottom [52], oblong block-bottom [51], and one kind of triangular bag [see 50], drawing, as in Class I., their supply from the web, but stopping the bag blank one or more times during the process of manufacture, while the bag blank is cut off from the web, the "bottom" folded, etc.

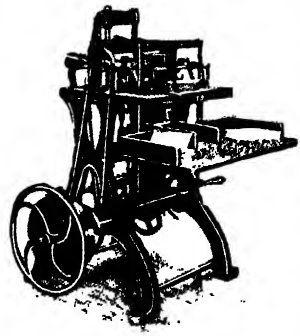
The speed on medium-sized bags varies from 35 to 60 per minute. The usual maximum size is the same as in Class I. The formation of these bags is almost exactly similar to hand work, an expert being required to point out the differences, which appeal more to fancy than utility.

Class III. are *machines which make from the sheet.* A few hand-fed machines for making large flat millinery bags are used, with indifferent commercial success; 20 to 25 per minute is their usual speed. These machines much resemble an ordinary folding machine, with pasting arrangements added. A more numerous class make the huge quantities of block-bottom bags required by the firms packing powder and grain goods. These machines automatically pick the sheet from the pile by suction or by an adhesive arrangement, fold it into a bag on a block, and deliver it, distended, fit for removal to the packing-room. They are necessarily operated by the firms themselves in the same factory in which the bags are used, because it would be impossible to transport the distended bags any distance. The

machines are slow (25 to 35 per minute), but the advantage of being able to use printed blanks, and the bags being distended ready for filling, compensate for their complexity and slowness.

A few machines are in operation automatically "working from the sheet," which make both "plain" and "block-bottom" bags "in the flat," but they are confined to large quantities of the same size of bag—nothing sufficiently universal and useful to the ordinary bag-maker seems as yet possible in this kind of machine.

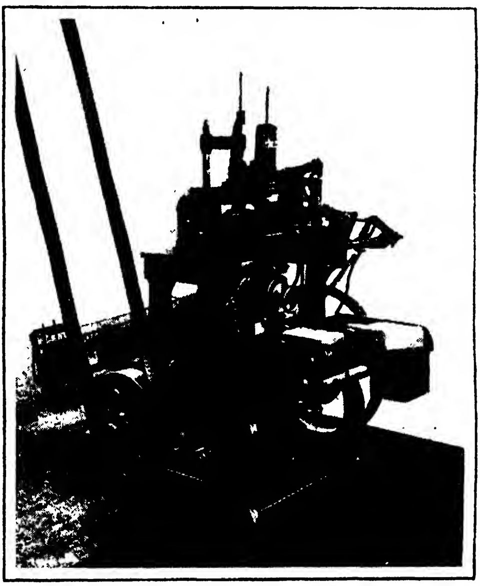
The folding of the bottom of a block-bottom bag is begun by means of what is called the diamond fold—that is, the flat tube of the bag is pulled into a diamond, usually lengthwise, of the bag. The two V ends are then folded inwards to complete the bottom. The V in oblong bags has a flat point. As in continuous action machines, the block bottom is always oblong, one of the V's has frequently a projection cut from the preceding bag in order to make the final seal of the pasting of the bottom. Many peculiar kinds of bag bottoms and bag shapes are occasionally met with, rendering bag-making an interesting study.



48. THE "REAY" ENVELOPE FOLDING MACHINE
(Joseph Richmond & Co., Ltd.)

Pasting Machine-made Bags. The pasting of all machine-made bags varies slightly from handwork pasting. All high-speed continuous action machines "work from the web," which is first pasted on one edge, hollowed into a U-shape, then closed over, and the edges lapped and stuck to form a flat tube. This tube is subsequently cut by differing devices into "bag lengths," and the bottom formed on one end of them. A few machines for very large plain bags work with two webs of paper instead of folding the tube from a single web, the edges of one of the webs being hemmed over, and pasted to receive and join to the covering web, the other operations being as usual.

Another machine hems and pastes the edges of a single web, cuts off a length double that of the bag, and then "dips" or doubles that length at its centre, the two hemmed edges coming together and forming a complete bag with the fold of the bottom.



49. "LEADER" ENVELOPE MACHINE
(David Carlaw & Sons)

Drying. Bags from high-speed machines are discharged from the machine to a drying device, usually a steam or gas-heated wheel or cylinder, where any paste which has exuded to the surface is dried, and the bags are thus prevented from sticking together when piled. The hot cylinders also press the bags, give them a neat finish, and greatly facilitate the thorough final drying. If a printing device is used, the regular delivery from the bag-forming apparatus is used for feeding the bags correctly to it.

The best *conical bags* made on continuous action high-speed machines are of kite shape when flat [see **50**]. This shape is a very convenient one to the shopkeeper. These bags can be printed immediately after discharge from the bag-forming portion of the machine, no drying cylinder being required.

Intermittent action web machines also draw from the roll, and in some instances tube it while being drawn to the cutting and bottom folding device. Others simply cut a sheet off the end of the web, and fold it over sideways before forming the bottom.

Printing Bags. The best class of printed bags, especially those printed on both sides, are usually printed "in the sheet," and then hand-folded, unless made into the distended bags before alluded to, in which case it is possible to fold them by machine. When hand-making is adopted, bags that are printed are always treated "in the sheet."

Plain bags and *simple satchel* bags can be readily and cheaply printed on one side at formation by an automatic printing device attachable to the bag machine, the other side being printed subsequently by ordinary process.

Block-bottom bags cannot be satisfactorily printed after formation, as the fold of the bottom covers much of the lower part of the face of the bag, and limits the space available for imprint: even when the trouble is taken to throw the bottom back too much space is lost. The delivery also from the machine making them is not so regular as with the plain and satchel machine.

Preventing the "Set-off." Many attempts have been made to print the web from which the bag is formed either in the bag machine itself or in the roll previously, but with indifferent success. The bag and the imprint may be made to "register," but there is great difficulty in preventing the "set-off" from the imprint depositing itself on the rollers of the bag machine, which in turn re-deposit the ink they rob from the imprint of the bag on to parts of the bag which ought to be free from ink. By disposing the imprint so as to miss the draw and holding rollers of the bag machine, this may be obviated, but such limit of imprint is unsatisfactory. The imprint on a bag requires to be full and heavy, so as to give good "display." This, of course,

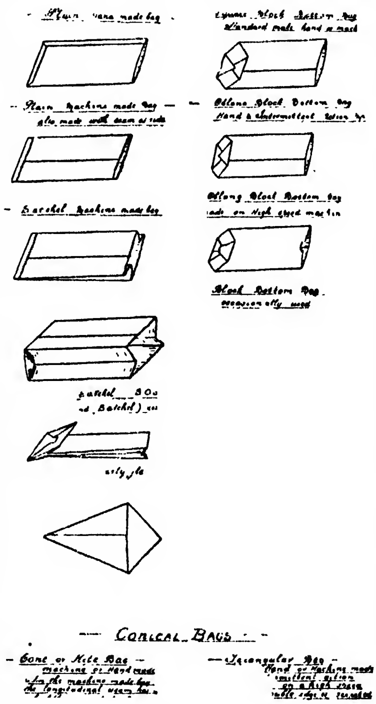
"sets off' easily—not as in newspaper printing, where the ink used is comparatively a mere trace. Even if the roll of paper from which the bags are made is printed months before the bags are made, the ink does not harden sufficiently not to give much trouble. This "set off" trouble prevents the immediately consecutive printing of the bags ("perfecting," as it is called) immediately at their discharge from the bag-forming portion of the machine.

PAPER BOX-MAKING

In making cardboard boxes, several different kinds of boards are used. The cheapest and that most generally used is strawboard. Another board largely used is wood pulp, made from wood in Scandinavia, Canada, and Finland. Leather board is used in wire-stitched and metal-cornered boxes when great strength is required. This board is made in Finland and Scandinavia.

The first process with a Johns, Son, & Watts plant is cutting the boards into pieces of the size required. This is done by passing them between two rollers, the upper roller being fitted with circular knives. Some of these are adjusted so that the board is only partly cut through, or, as it is called, "scored." The boards then pass through a second time at a right angle to the first, and are similarly cut and scored, the double process leaving the board in pieces, as at A in 55, the dotted lines representing scored marks. These pieces are put in numbers before taking out the corners. B and C show the appearance after the corners are removed. In 55, D shows the appearance of the board when bent along the scored lines.

This process takes place only with shallow boxes, the deeper boxes being made in three pieces to save material. The body of the box in one piece [D] and the ends separate [E]. The ends are then attached to the box by means of the strong paper or calico [F].



50. TYPES OF BAGS

On completion of process B, the box is in the flat, ready to be bent up along the score marks, and joined at the corners with calico or paper, according to the strength required. The covering is next put on after having been cut by a guillotine into pieces the size required.

An endless band revolves down the centre of the work-table. At one end a girl glues the papers on a roller, places them on the band, to be taken off by the worker who requires them, as they pass, and put them on the boxes.

The larger quantities of boxes, however, are joined up and covered by machinery. The box is bent up into position, and each corner in turn held on an anvil, the joining-up material being affixed by means of a plunger, which cuts the material off the required length in the fixing. The box is now placed on another machine on a block, which can be adjusted to the size of box required.

On this machine a roll of paper cut to the width desired is passed over a glued roller and the end stuck to the box. The block revolves, gluing the paper to the box as it does so, and at the completion of the revolution the paper is cut automatically.

Fancy boxes are made entirely by hand, and are covered with artistically designed papers, or some material, such as silk, satin, or plush, and hand-painted, and decorated with metal to give a very pleasing effect.

These are used for the sale of higher class confectionery, handkerchiefs, gloves, etc., and for presentation caskets at City dinners and such occasions. To improve the appearance of the strawboard, a white or coloured enamelled paper is affixed, thus ensuring a clean and smooth surface.

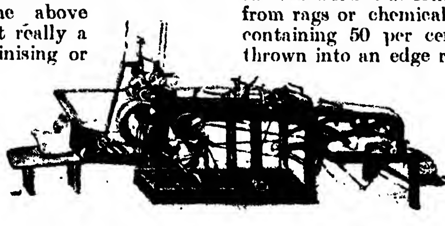
Large numbers of folding boxes or packets are made; these are more convenient for many purposes than the ordinary box, being cheaper and taking up less room for storage. A stronger board has sometimes to be used, and if strawboard is required, a strong paper lining is put on the board to prevent cracking. A strong manilla board is commonly used. This type of box has a large consumption among chemists, soap-makers, tobacco manufacturers, etc. The wire-stitched and metal-cornered boxes are used by milliners, drapers, tailors, and for postal purposes. The metal corners have serrations or teeth that grip into the board, and a box made in this way will sustain very great pressure.

Cardboard rolls for postal and other purposes are made of common strawboard, by coating one surface with glue and rolling on a mandrel in contact with a revolving cylinder, which exerts great pressure, making a very firm and solid roll. Fluted and corrugated packing paper is prepared from strawboard by passing one portion between fluted rollers, whence it emerges in corrugated form. It then comes into contact with and is glued on to a thin strawboard.

SOLVENTS FOR FIBRES

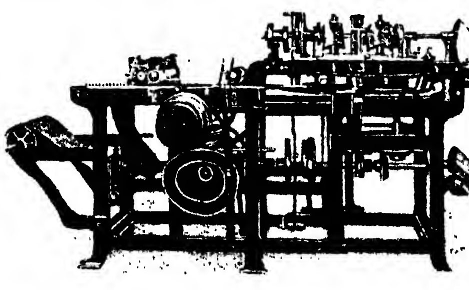
An important industrial application of a solvent for cellulose, or a profound change as the result of chemical treatment upon cotton and other vegetable fibres may be said to date from the discovery of parchment paper. This the student can produce for himself in the laboratory by taking filter paper and plunging it under sulphuric acid previously diluted with from 20 per cent. to 25 per cent. of its volume of water and cooled. The paper becomes transparent and swells up, and the fibres become gelatinised and would, if left in the acid, go into solution. At an early stage, however, the paper is removed, thoroughly washed free from acid and dried. The resulting product is a hard parchment-like material which retains its strength on wetting. This product is produced on a large scale by

passing a continuous web of water leaf paper through a bath which can be lead-lined, but is preferably of glass or porcelain. This bath contains the acid. The web then passes through a succession of baths containing water, which removes the acid. The first washings are recovered by concentration, the later ones are run to waste. The last bath may contain a little ammonia to neutralise the last traces of acid. The above parchmentising effect is not really a solvent action but a gelatinising or hydrating effect, the gelatinised fibres gluing themselves together with their own substances on drying.



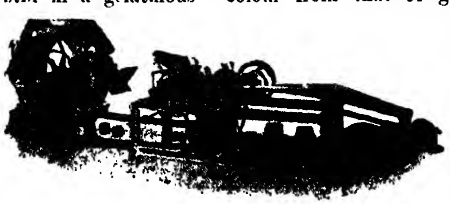
51. OBLONG BLOCK-BOTTOM BAG MACHINE

Cupramonium as Paper Solvent. This is prepared according to the patent of D. C. R. Alder Wright (737, 1883). Towers about 12 ft. high are arranged so that a current of air can be successively blown through them. They are filled with fragments of copper turnings or crumpled up sheet and ammonia solution. The air passing through oxidises the copper, which is dissolved in the ammonia, producing a blue solution. A good commercial result is got from 100 lb. to 150 lb. of ammonia, and 20 lb. to 25 lb. of copper are contained in 100 gallons of the solvent. The student can prepare some of this solvent in the laboratory by pouring ammonia repeatedly through a funnel containing copper filings. If, at the same time, some cotton-wool is present, he obtains a cupramonium solution of cellulose.



52. SQUARE BLOCK-BOTTOM BAG MACHINE

Willesden Paper. This is prepared single ply by passing a continuous web through a bath of the above solvent and drying off the ammonia, or a welded material of several ply is obtained by amalgamating several thicknesses. Thus, if two or more sheets of paper are dipped into the bath and pressed together while the surface is still in a gelatinous state, they produce one compact mass. In order to recover the ammonia the paper or fabric is dried in closed chambers, the ammonia vapour from which is recovered. The paper is strong, durable, rot-proof, and less inflammable than ordinary paper. It has a pale greenish or bluish colour due to the presence of copper, which, however, can be rendered colourless or nearly so by substituting zinc for copper.



53. MACHINE FOR MAKING OBLONG-BLOCK PAPER BAGS (Strachan & Henshaw, Ltd.)

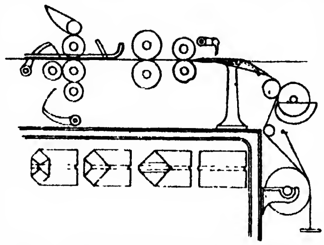
Viscose. Cross, Bevan, and Beadle discovered that vegetable fibres could be rendered soluble by treating successively with strong alkalies and carbon bisulphite. This was patented in 1892, which patent has formed the nucleus of some very important commercial developments. Various classes of raw material can be used, such as rag, beaten to pulp and pressed into cakes, waste fibres from paper-mills, chemical wood pulp, but in the laboratory one can use either cotton-wool or, better still, pure filter paper.

The Mercerising Process. The first process is known as "mercerisation," and in some cases is worked as follows: Well beaten paper pulp from rags or chemical wood is pressed to cakes containing 50 per cent. of moisture. These are thrown into an edge runner, ground up, and to the mass is added a strong caustic soda solution. This causes the fibres to swell up like so many snowflakes, due to the action of the strong soda upon the cellulose, resulting in the formation of a chemical compound known as alkali cellulose. The discovery of mercerisation is an old one, due to Mercer, and has recently been made use of in connection with the textile industry; but its application in this manner as a stage in the production of a solution of cellulose was unknown up to the time of the discovery of viscose.

Making Fibres Soluble in Water. The mercerised product, called often *alkali cellulose*, is put into convenient receptacles, where it is stored at a certain temperature away from the air. When of the right degree of "ripening" it is transferred to revolving tubs or jars to which is added carbon bisulphite, and at a given temperature the alkali cellulose and bisulphite interact, giving rise to a product known as *cellulose thiocarbonate*. The original mass from being fibrous and spongy changes gradually to sticky, buttery fragments of a bright yellow colour. This mass, if incorporated with water, produces a solution of cellulose thiocarbonate of about the consistency of molasses, but varying in colour from that of golden syrup to molasses, according to the manner in which it has been prepared, and the purpose for which it is intended. The above description may sound simple enough, but the various stages are far more complex in commercial practice. Thus, the exact kind of raw material used, its mechanical treatment, the exact proportions of the ingredients, the temperature and the time allowed between each stage are all factors which have to be studied and controlled to suit the purpose for which the soluble mass is to be applied; and it is of absolute importance that such details should be minutely studied. Books have already been written dealing with this one product, and an examination of the Patent Office records shows the number of patents from time to

time taken out covering its various applications and modes of preparation.

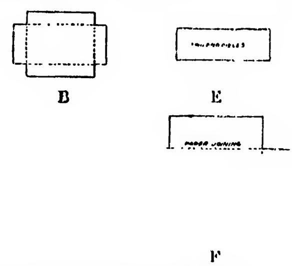
To this solution the name of "viscose" is given on account of its extremely viscous qualities, which can be varied almost indefinitely according to details of manufacture. Viscose, if stored, undergoes changes; in fact, the solution is undergoing a cycle of molecular changes from the moment of its formation. It ultimately coagulates to a gelatinous or rubbery mass. On immersing in water, and by occasionally changing the water, the rubbery mass is deprived of its chemical by-products, leaving a cellulose jelly (hydrate of cellulose). This, on drying down by exposure to the air (dehydration), becomes a hard, horny mass (regenerated cellulose), to which the name *viscoid* is given.



54. DESCRIPTIVE DIAGRAM OF OBLONG BLOCK BAG MACHINE

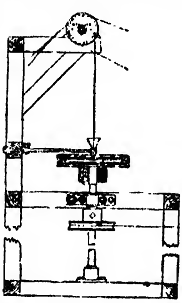
Coagulation. The coagulation is accelerated by heat. Thus, if a thin varnish of the viscose on glass be placed in an oven, in a few minutes it will be dry and coagulate. On plunging this under cold water, a film is procured, which, on drying and pressing, is not unlike a collodion film in appearance, but it softens more in water.

The viscose solution can be used for impregnating cloth, paper, webbing and various articles. On drying down, these products are stiffened or sized and in some cases found to possess waterproof qualities. One great fascination about this product is its protean qualities, which are controllable by a variation of the conditions under which it is manufactured. This makes the product an interesting, although a difficult, study.



55. DIAGRAMS ILLUSTRATING BOXMAKING

Dissolved cotton as viscose can be thrown down from its solution by diluting, warming and agitating. The flocculent mass of cellulose so produced is washed, chemically purified and dried as to a powder. Viscose has been worked in a plastic as well as a liquid condition by suitable machinery, when it is capable of incorporation with various plastic and mineral products, as by the method of incorporation patented by Beadle. The resulting mass when finished is capable of conversion into articles resembling in appearance those made from ebonite, celluloid, vulcanite, ebony, etc.



56. SPINNING BOX

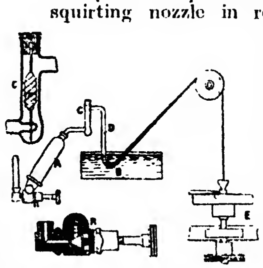
Viscose Artificial Silk, or Lustra Cellulose. In 1894 Stearn projected a solution of viscose through a small orifice into a precipitating or setting solution, which converted the liquid into a solid filament. Viscose has the peculiar property of being solidified by such substances as brine, sulphate of ammonia, etc., so that if a thin thread of liquid be projected into a bath of such solution, it becomes a solid thread. Products of this nature when finished to resemble silk, are called *lustra cellulose.*

Improvements were made by Topham for filtering the solution by passing it through various filtering media to deprive it of every particle of dirt or fibre, the plant being so arranged that every particle of air is eliminated [57]. This is absolutely necessary, or the nozzles would otherwise get blocked and the threads broken. The manner of manipulation now is that a number of threads, perhaps 12 at a time, are drawn through a perforated plate, immersed in the setting solution [B 57], then over a pulley, and then are twisted together by an ingenious spinning contrivance [E 57 and 53], where centrifugal force is taken advantage of in giving the filaments a pull and a twist; the thread is laid as an annular mass which is periodically removed from the box.

In the production of artificial silk absolute control in every respect was found to be essential. Thus, the rate of flow had to be automatically regulated. This is done by a glass valve fitting a tube [C 57], and floating in the solution and covered on its surface with veins or spiral grooves, through which the solution finds its way, causes the valve to rotate, and by the position of the float, the supply is automatically controlled, and delivered in a regular stream from the pump to the squirting nozzles. This valve can be set to alter its delivery according to requirements.

Important improvements rapidly followed in all stages, including the preparation of the viscose, dissolving, agitating, stirring, spinning, precipitating, and in the subsequent treatment of steaming, washing, purifying, bleaching, drying, etc.

Care Required in Spinning. It will readily be realised that the diameter of filament is dependent upon the pull or "draft" from the squirting nozzle in relation to the amount of solution passing through the fine orifices, and that this has more to do with the fineness of the thread than the actual diameter of the holes through which it passes. The lustre, feel, elasticity, and physical qualities generally, are affected and controlled by such considerations. But apart from these, and the chemical and physical qualities of the liquid viscose, the processes that follow the first formation of the thread produce profound modifications, such as stretching while steaming and drying under tension are important in their influences. The appearance of viscose filaments under the microscope affords useful data, and throws light upon the more exact manner of its formation. The tendency is to the formation of



57. VISCOSE SPINNING PLANT

tubes, with a fine capillary hole through the centre. The viscous filament, immediately on its first contact with the precipitating or setting agent, naturally sets on the outside. When dehydration takes place, the plastic interior accommodates itself to the rigid exterior, hence a hollow thread is produced, unless the same is microscopically fine. A pull exerted upon the thread while it is in a semi-plastic condition—that is, before it is rendered insoluble by steaming—will greatly lengthen it, at the expense of its diameter. This is the more readily understood with a hollow tube, hence the diameter may be much diminished by increasing the pull while the supply to the squirting nozzles is kept stationary.

Viscose Filaments. The filaments are not necessarily circular; in fact, magnified sections show them to be angular, due, no doubt, to their contact one with another while still in a mouldable condition. Exactly the same influences are at work in a state of Nature, as with flax and esparto fibres. When a bundle of fibres are pressed evenly together, either by reason of their internal growth and expansion or pressure upon them exerted laterally, the tendency is to the formation of tubes, hexagon in section. Stearn confined his attention to the problem of rendering viscose a homogeneous product, discovering a suitable precipitant that would enable the spinning to be done at a high speed, and investigating the physical changes that occurred during the ripening, and to devising mechanical appliances for producing a uniform product.

In the course of development it became manifest that careful preparation of the solution was of paramount importance. This had to be attended to at every stage, and there is as much science and skill needed to accomplish this as is necessary in the brewing industry, perhaps even more so.

Ageing. We have already stated that the viscose solution is undergoing molecular changes from its very inception to the time of its coagulation. For spinning, the solution has to undergo a process of "ageing," and further chemical treatment, and at the right stage it is spun so that the filament becomes coagulated or solidified *while still in a soluble condition*, and is subsequently rendered insoluble. This important advance we owe to Stearn. Viscose silk [58] is now prepared in large quantities. It possesses the most beautiful lustre and excellent qualities for spinning and weaving. It takes colours either by adding these to the original solution or by dyeing the hanks or skeins in suitable dye-baths. Its silky sheen or gloss results largely from the manner in which it is dried. Its physical qualities in comparison with those of real silk and other artificial silks, have from time to time been referred to in technical and scientific journals.

Very much coarser filaments can be produced from viscose containing hair and fine gut.

The actual production of factories for artificial silk was estimated (1904) at about 1,500,000 kilos, equal to 6 per cent. in comparison with the natural article. The production at first was slow, but there are now a number of factories producing the artificial product, and artificial silk, by one or other of the well-known processes, is likely to become one of the most important industries of the future. A minute examination of the history of these several processes is perhaps one of the most valuable object lessons to the young aspiring chemist.

A monograph on "Cellulose" by Cross Bevan and Beadle (Longmans, 12s.), and later publications might with advantage be consulted by students who desire a closer acquaintance of the chemistry of the subject.

58. SKEIN OF VISCOSE SILK

COLLODION SILK

Such is the name given to artificial silk made in accordance with Chardonnet's patent, and others who have had to do with the development of this industry. It is prepared by dissolving nitro cellulose in a mixture of ether and alcohol, and forcing it through glass capillary tubes, with fine orifices, into the air. The solvent evaporates with sufficient rapidity to allow the filaments to be wound up continuously, leaving the thread insoluble. This is the gist of the process, but in detail it is full of complexities, like that of the viscose product.

Dr. Lehner, of Zurich, after investigating the various problems involved, found that, whereas ordinary collodion containing such a proportion of the pyroxylin (10 per cent. to 12 per cent.) in solution is unworkable under the prescribed conditions, the adding of dilute sulphuric acid causes a molecular change, and gives the solution the requisite fluidity. With such a solution, the conversion into thread is effected as follows. The solution, if carefully filtered, and free from all bubbles, is caused to flow by way of glass tubes to a lower level, where it is delivered through a much narrowed opening with a steady constant flow. The shorter limb ending in this fine orifice is contained in a glass cell, filled with water. On emerging therefrom the solution is at once coagulated to a transparent jelly of considerable toughness. On applying a slight pull to the jelly, grasped with the fingers or forceps, a thread is produced, and on fixing the end to a light wheel revolving at a definite rate, the thread is drawn off continuously of uniform diameter. Several threads being twisted together in the usual way of "silk throwing," the artificial textile thread is produced. After being deprived of water of hydration, the threads acquire the high, white lustre of "boiled-off" silk.

The "artificial silk" has been found to have tensile strength equal to 70 per cent. of that of the natural product of the same degree of fineness. Its elasticity is inferior in about the same proportion; but it has a higher lustre, and is produced at much less cost. Its individual use is, therefore, likely to be considerably extended in the near future.

PAPER-MAKING *concluded; followed by* PHOTOGRAPHY

THE MOON AND THE PLANETS

The Moon's Orbit and Eclipses. The Braking Effect of the Tides. The Superior Planets. Life on Mars. "Mountains Broken Loose." The Perplexing Comets

Continued fro page 6405

By W. E. GARRETT FISHER

The Moon and Her Orbit. The earth, like most of the planets, has a satellite, known as the moon, which moves round it in an elliptical orbit, just as the planets move round the sun. Its globe is rather more than one-quarter that of the earth in diameter, measuring 2,163 miles. It revolves round the earth in an orbit, which, like that of the earth, is an ellipse; but it is not so nearly circular as that of the earth, its eccentricity being about $\frac{1}{18}$. Thus, the actual distance of the moon from the earth varies from about 250,000 miles to 220,000 miles, while the mean distance is 238,840 miles, which is about 60 times the earth's radius. The moon takes about 27⅓ days to complete her revolution round the earth; in other words, she makes a complete circuit of the heavens, from a given star back to the same star again, in that time. Her revolution with regard to the sun, however, on which her phases depend, is not completed in this period, because it is complicated by the earth's motion round the sun. This *synodic* period, of which we usually speak as a month, averages about 29½ days, which is the mean period between successive new moons. The *phases* of the moon depend upon the place which she occupies with regard to the sun as seen from the earth, as has already been explained in the case of the planets Mercury and Venus [27]. When the moon lies between the earth and the sun, the dark side is turned to us and the moon is new. When the earth lies between the sun and the moon, we see our satellite fully illuminated, and speak of her as full. Her degrees of illumination vary steadily between these two extremes in the course of every fortnight. Every night the moon bears a different appearance, waxing through one-half of the month and waning through the other.

26. LINES OF TOTAL SOLAR ECLIPSES

Eclipses of the Moon. If the orbit of the moon lay in the same plane as that of the earth—the plane of the ecliptic—it is obvious that she would pass directly between us and the sun once in every month at the time of new moon, and would then obscure the sun for the length of time which she took to complete her transit. This does occasionally happen, and the consequent blotting out of the sun for a few minutes is known as a *solar eclipse*. Similarly, when the moon was full, the earth would lie in a straight line between her and the sun, and the earth's shadow would blot the moon out of sight by depriving her of the illumination by which alone she becomes visible. This also happens occasionally, and the result is a *lunar eclipse* [30]. But, as a matter of fact, the moon's orbit does not lie in the same plane with that of the earth, but is inclined to it at an angle of about 5°. Consequently, the moon, when lying in the same direction as the sun, is usually a little above or below our luminary, and there is no eclipse.

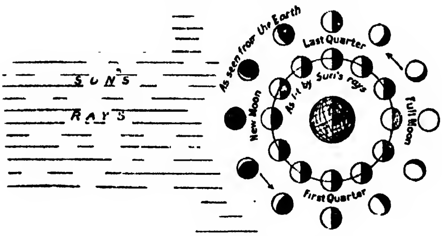
A solar eclipse can only take place, in fact, when the moon lies in the direction of the sun, or is new, near the moment at which she passes the *node*, or point at which her orbit intersects the plane of the ecliptic, which hence derives its name. The same is true of the lunar eclipse, which only occurs when the moon is close to one of her nodes at the time of being full, and, consequently, passes into the shadow of the earth. It follows from geometrical considerations that there cannot be less than two or more than seven eclipses in a year, of which at least two must be solar. From the computed motions of the earth and moon we find that the conditions which determine eclipses repeat themselves with great exactness after a period of about 18 years and 11 days. This recurrence of eclipses was discovered from observations by the Chaldeans, who named this period the *Saros*, and were enabled to predict coming eclipses by its use.

Eclipses of the Sun. There is a notable distinction between solar and lunar eclipses, which also depends upon the relative movements of the earth and the moon. A lunar eclipse is visible from all parts of the earth where the moon is above the horizon; and a moment's thought will show us that this must be so, because an eclipse of the moon is due to the moon entering into the shadow of the earth, and is exactly comparable to the switching off of an electric light. Wherever the moon can be seen at all—even from Mars—it will be eclipsed. But this is not at all the case with a solar eclipse, which only exists for observers who occupy a narrow belt of the earth's surface. A solar eclipse simply means that the moon passes between us and the sun, and that the earth itself lies for a few minutes in the shadow of its satellite. Now, everybody knows that the breadth of a shadow depends upon the relative size and distance of the object which casts it. The sun is incomparably larger than either the earth or the moon, and, consequently, the shadows which they cast are both conical, like the point of a pencil tapering off to an abrupt end.

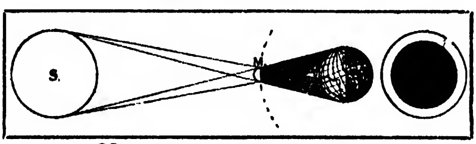
The earth's shadow is much longer than the moon's, in exact proportion to the relative size of the two bodies. Thus the moon takes a considerable time to pass through the earth's shadow, and may be totally eclipsed for as much as two hours. But the moon's shadow is only just long enough to reach the earth at all. The largest possible cross-section

of the moon's shadow where it reaches the earth's surface is about 168 miles; and as the shadow sweeps across the earth from west to east, it is only observers situated within a belt no wider than this who will see the sun *totally* eclipsed [26]. Outside this belt a *partial* eclipse will be visible over a very much greater area, its size decreasing as the distance from the belt of totality increases.

The width of the eclipse-belt, and the consequent duration of totality, vary between wide limits with the distance of the moon from the earth at the moment of eclipse. The moon's apparent size is very nearly that of the sun, each being a little over 30 minutes in diameter. But these both vary with the distance of the earth from the sun and moon, and it sometimes happens that at the time of an



27. PHASES OF THE MOON



28. ANNULAR SOLAR ECLIPSE

eclipse the moon is so far away that its shadow does not quite reach the earth, and its apparent diameter is rather less than that of the sun. At such a time we see an *annular* eclipse [28], in which at the moment of greatest eclipse a bright ring of the sun's disc is still visible surrounding the moon. It is on observations made during the brief duration of total eclipses of the sun that astronomers long depended for their chief knowledge of the solar constitution, and that they are still dependent for their study of that mysterious object, the corona.

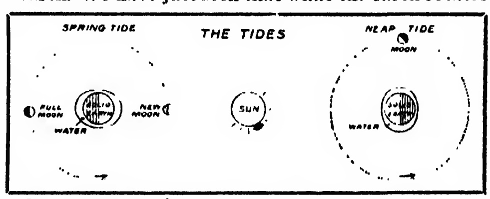
The Moon and the Tides. The gravitational attraction of the moon has a very important influence on the earth in causing *tides* in the sea. The way in which these tides are caused will be easily understood from a glance at the diagram [29].

We have seen that the attraction of one body for another varies inversely as the square of its distance. As the waters of the sea on the side of the earth nearest the moon are nearer our satellite than the centre of the earth, the moon pulls these waters towards her with greater force than she exercises upon the body of the earth; and as they are quite free to move, they are consequently heaped up in a kind of watery mound, which is highest on the spot vertically beneath the moon. In exactly the same way the moon attracts the earth more powerfully than the water which lies on its opposite side, and so draws the earth away from that water, which is consequently heaped up into a similar mound on the point exactly opposite. Thus we have two simultaneous high tides, culminating at the two points of the earth which lie in a straight line with the moon, and, consequently—since the total amount of water in the seas does not vary—corresponding low tides at two points on the earth distant by 90° from these.

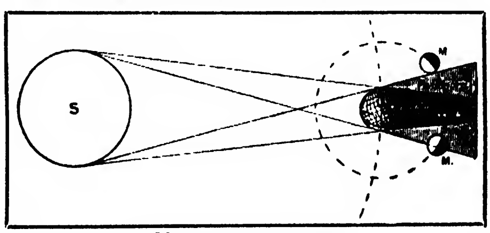
If the moon were fixed with regard to the earth the tide would always be high at one set of places and low at another, but as the earth completes a rotation in twenty-four hours, whilst the moon holds its accumulations of water in the same place, the high tide and low tide traverse every part of the seas, there being two high and two low tides at each place daily. If the earth were a perfect sphere, uniformly covered with water, this state of things would be actually observed by its fishy inhabitants. But the configuration of its surface greatly complicates the actual motion of the tides, which are greater or less, sooner or later, according to the shape of the coast line, as is explained in the course on GEOGRAPHY [page 556].

Spring and Neap Tides. The sun as well as the moon helps to create tides in our seas. Its mass is very much greater than that of our satellite, but so is its distance, and, consequently, the solar tide is only about two-fifths as high as that caused by the moon. When the sun and the moon lie nearly in the same straight line with the earth, and the moon is new or full, the solar and lunar tides help one another, and we have extra high tides, known as *spring tides.* When the sun and moon lie at right angles to one another with regard to the earth, and the moon is in its first or last quarter, their tidal forces are opposed, and moderate or *neap tides* result. It will readily be seen that the average height of the spring tide should be rather more than double that of the neap tide at any particular place.

How the Day has Lengthened. One very interesting effect of tides, as Sir George Darwin has shown, is to act as a brake upon the rotation of the earth. We have just seen that while the earth rotates



29. THE MOON'S GRAVITATIONAL ATTRACTION



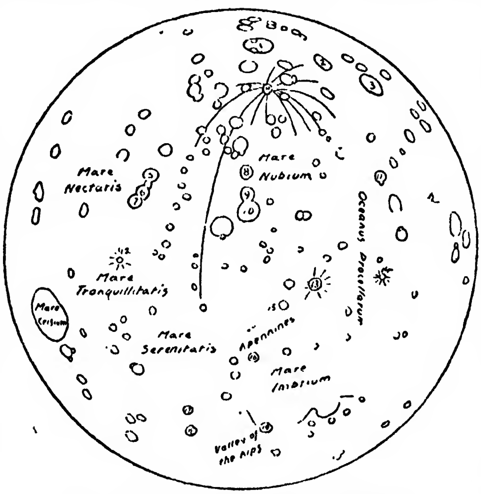
30. LUNAR ECLIPSE

a great mass of water is held still by the attraction of the sun and moon. This acts exactly like the brake which is used on the axle of a wheel, and by its friction tends to diminish the rate at which the earth rotates. In the early days of the earth this effect was much more considerable than it is at present, and Sir George Darwin has shown that tidal friction has lengthened the day from about three hours to its present length, and that the moon itself almost certainly once formed part of our planet and was thrown off from it by the centrifugal force due to this extremely rapid rotation. When the earth was still in a liquid condition, tides were caused in its actual substance by the attraction of the sun,

and afterwards possibly of the moon, and the retarding effect of these gigantic tides, which may have risen as much as 600 miles in height, must have been immensely great. At present there is ground for believing that the tidal friction is still exerting a retarding influence on the earth's rotation; but this influence is exceedingly small, and it is practically certain that the length of the day has not varied by so much as one-hundredth of a second since the dawn of astronomy 2,000 years ago.

The Physical Condition of the Moon. As we have seen that the moon was originally a fragment drawn away from the earth, it is only reasonable to suppose that it is composed of the same materials. But it differs from the earth in one very important respect. Being so much smaller it has cooled more quickly, and has probably passed through all the stages of planetary life, in the midst of which the earth is now.

Few things are more certain than that the moon is a dead world. It has no atmosphere, so far as we know, and if one exists it must be more rare than the vacuum inside the incandescent electric lamp. Such air and water as the moon must once have possessed have been absorbed into its substance or flown away into space. One consequence of its denuded condition is that the surface of the moon must undergo extremes of heat and cold. The side on which the sun is shining must be far hotter than the tropical regions of the earth, whilst the other side must endure the cold of empty space, which is very near the absolute zero of temperature. It is hardly necessary to add that the moon cannot be the abode of any kind of life which we can conceive as possible. Life may once have existed there, but it is long extinct.



31. MAP OF THE MOON'S SURFACE

The Face of the Moon. The moon is a globe about 2,163 miles in diameter, and its mass is about $\frac{1}{81.5}$ of the mass of the earth. Its density is about 3·4, that of water being taken as unity. The moon rotates on its axis in 27 days $7\frac{2}{3}$ hours, so that its day and night are each a fortnight in length. This period is the same as that in which it revolves round the earth. The moon, consequently, always presents the same face to the earth; though, as a matter of fact, we are able to see rather more than a single hemisphere of the moon because of a certain oscillating motion of our satellite known as *libration.*

But there is a considerable portion of the moon's surface, amounting to more than three-eighths of the whole, which is permanently invisible to the observer. Novelists have allowed their imagination to run riot about this invisible side of the moon, and have provided it with an atmosphere, flowing water, and inhabitants. But it is as certain as anything of the kind can be that the invisible half of the moon is perfectly similar to that which we see.

The chief feature of the moon's visible surface is the numerous and often gigantic craters with which it is pitted [32 and page 1206]. These objects, when observed through a telescope, or even a powerful field-glass, have a striking resemblance to volcanic craters on the earth. They are, indeed, on a vastly greater scale, some of them being more than 100 miles in diameter. But there is little doubt that they are the remains of extinct volcanoes which once covered the moon with violent and long-continued eruptions. Probably the surface of the earth was once in a similar condition, but the existence of the various denuding agencies which our planet possesses have entirely changed the configuration of its surface [see GEOLOGY]. No distinct evidence of volcanic activity has been seen upon the moon in modern times, though a few observers believe that they have noticed very slight changes of this nature in progress. It is most probable that the moon is a dead world, affording a kind of prophecy of what the earth will be one day, when it also pursues a frozen and lifeless journey through space.

Selenography. The surface of the moon has been studied and mapped on a large scale [31]. Its chief features are three in number: (1) the numerous *volcanic craters,* such as Tycho and Copernicus, which are mostly named after distinguished men of science: (2) the wide, dark plains which are known as *seas,* because they were formerly thought to consist of water: (3) the curious systems of *bright streaks,* which radiate from many of these craters, of which the most remarkable extend in all directions from the great crater Tycho, near the moon's south pole, and are conspicuous even to the naked eye at the time of full moon. The student will find the names and description of these various features of lunar topography—*selenography* — in any good textbook of astronomy, but they are not sufficiently important to demand fuller treatment within our narrow limits.

The Superior Planets. The *superior* planets are all more distant from the sun than the earth. They include five major planets—Mars, Jupiter, Saturn, Uranus, and Neptune—as well as a vast number of minor planets, of which nearly 600 are known at present. These outer planets differ from the inner planets, Venus and Mercury, in the nature of their apparent motion. Instead of oscillating backwards and forwards across the sun, they all move, on the whole, steadily westward in respect to the sun's place in the heavens, and consequently rise earlier and come earlier to the meridian every night. It is obvious that they can never pass between us and the sun as the inferior planets do at the time of transit.

The superior planets may appear in any part of the Zodiac, outside the limits of which, however, they never move. This is due to the fact that they all move round the sun in elliptical orbits outside that of the earth. When a planet lies beyond the sun in a straight line with the earth it is said to be in *conjunction*; when the three bodies are in a straight line, but the planet is on the opposite side of the

earth to the sun, it is said to be in *opposition.* Of course, we can never see the planet in conjunction, because it is only above the horizon in the daytime, when the light of the sun obscures it. The superior planets can be best studied when they are in or near opposition, because at such times they are nearest to the earth, and are also most favourably illuminated. They do not display phases like those of the moon. A necessarily brief account of the physical features of these various planets will now be given.

Mars, the Red Planet. Mars, the major planet which comes nearest to the earth, with the single exception of Venus, resembles the earth more closely than any other of the planets, and is most favourably situated for our observation of all the heavenly bodies, except the moon. It is a globe rather more than half the size of the earth, its diameter being about 4,200 miles. Its mean distance from the sun is 141,500,000 miles, but the eccentricity of its orbit is so considerable that this distance varies by more than 26,000,000 miles. When Mars comes nearest to the earth its distance from us is about 35,000,000 miles. At these favourable moments its brightness is about equal to Jupiter, and only surpassed by that of Venus. Mars has a very pronounced red colour, which is supposed to be due to the prevalence of a rock like our red sandstone on its surface, or possibly to the colour of its vegetation.

32. MOON'S SURFACE SHOWING CRATERS

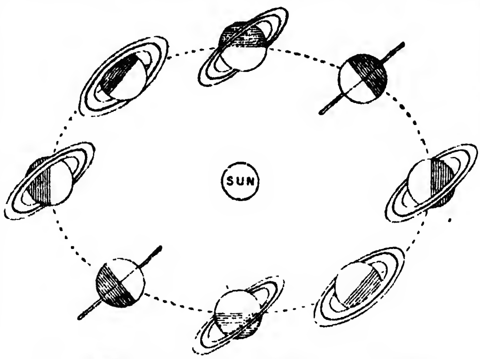
The Most Likely Seat of Extra-terrestrial Life. When studied through a powerful telescope Mars reveals itself as having a physical constitution very like that of the earth [37]. It undoubtedly possesses an atmosphere, though this is much less dense than that of the earth, so that clouds are of very infrequent occurrence in it. Mars also possesses free water, which is collected into seas on its surface and gives rise to extensive caps of ice around its poles. These ice caps are observed to dwindle in summer, and increase in winter, so that their nature can hardly be doubted. The surface of Mars is divided, like that of the earth, into continents and oceans. The most peculiar feature in its land is the presence of numerous straight narrow markings which are commonly known as canals [36]. They are not indeed canals such as we make on the earth, for they must be at least 60 miles in width in order to be visible to us at all. But there is little doubt that they represent watercourses of some kind.

The most curious thing about these canals is that they are not always visible. They seem at times to disappear from sight and then again reappear, and this in accordance with the periodical changes in the Martian seasons. It has been plausibly suggested that the marks which we see are not the actual watercourses, but the broad belts of vegetation which come into existence when the water is turned on to irrigate them, and die when it ceases to flow. It has even been suggested that this periodical flow and cessation of water is due to the enterprise of the hypothetical inhabitants of Mars. At present this theory rests on inference, but there is a great deal to be said in its favour, and the astronomers who have studied Mars most closely are most nearly convinced of its truth. We know that Mars, being an older planet than our own, is farther advanced in evolution, and that it has reached the stage at which efforts far greater than any which mankind is yet called upon to put forth must be necessary for the preservation of life on its surface. Its water supply is already becoming scanty, and some gigantic system of irrigation would undoubtedly be necessary for its surface to continue fruitful. It is possible that the markings which we call canals do really represent such a system of irrigation, but we can hardly say more than this about the great problem of the existence of life in this planet.

Satellites of Mars. Mars has two satellites, which were only discovered as recently as 1878, although their existence and many of their characteristics had been strangely predicted by Swift in "Gulliver's Travels" more than 150 years earlier. They are exceedingly small, swift, and close to the planet. The outer one revolves at a distance of 14,600 miles from the centre of the planet in a little more than 30 hours, whilst the inner one is at a distance of only 5,800 miles, and revolves in 7 hours, 39·25 minutes. Mars itself rotates in 24 hours 37½ minutes. Consequently, its inner satellite completes more than three revolutions in every Martian day. To a Martian observer it will appear to rise in the west and set in the east, completing its apparent revolution in about 11 hours; for, of course, it revolves in the same direction as that in which the planet rotates. It is impossible to estimate the size of such a tiny object with any accuracy, but we can be sure that neither of the satellites is more than 30 or 40 miles in

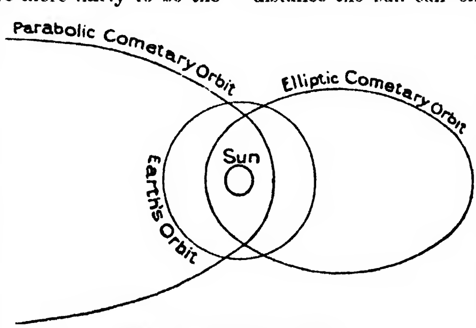
diameter, and probably they are even smaller than this. Mars completes its revolution round the sun in 687 days, so that the Martian year is nearly double our own in length.

The Minor Planets, or Asteroids. The space between Mars and Jupiter is occupied by a strange and numerous swarm of *minor planets* or *asteroids*. The first of these singular bodies was discovered by an Italian astronomer, Piazzi, on the first night of the nineteenth century. Three others were discovered within the course of the next seven years, and the number now known is upwards of 600, most of which have been recognised by the record of their motion on photographs of the sky. The four asteroids first discovered, Ceres, Pallas, Juno, and Vesta, are naturally the largest, ranging in diameter from 488 to 118 miles.



33. METEORIC RINGS GIRDLING SATURN

Vesta, though not the largest, is considerably the brightest of the minor planets, and is occasionally visible to the naked eye. None of the other asteroids has a diameter so great as 100 miles, and probably the majority of them are only 10 or 20 miles in diameter—mere " mountains broken loose," as they have been called. Most of these planets move round the sun in orbits which lie between those of Mars and Jupiter, and all of which intersect one another. There are a few exceptions to this rule, notably in the case of Eros, discovered in 1898. The orbit of this planet lies between Mars and the earth, and it is by far our nearest neighbour after the moon, its minimum distance from the earth being 13,500,000 miles. So close an approach will occur in 1931; it gives Eros a particular importance, as observations of it made at such a time should enable us to determine the solar parallax with greater accuracy than has hitherto been achieved. It was formerly supposed that these minor planets were the disrupted fragments of a planet which had been blown to pieces by some internal convulsions. It is now held, however, that they are more likely to be the remains of a part of the original nebula which never coalesced into a planet, as will be explained later on.



34. COMETARY ORBITS

Jupiter. By far the largest of the planets is the giant Jupiter, which is more than twice as massive as all the other planets put together. Its mean diameter is 88,000 miles, and its mass is about 317 times that of the earth, though its mean density is not much greater than that of water. Its mean distance from the sun is about 483,000,000 miles, or rather more than five times the earth's distance, which is taken as the astronomical unit. It completes its revolution round the sun in 11 years 10 months, though it appears to revolve round the earth in a synodic period of 399 days. Jupiter is the brightest of all the planets except Venus, which, though so much smaller, is much nearer to us and better illuminated. Jupiter rotates on its axis in rather less than ten hours, so that a point on its equator must be travelling at the rate of seven or eight miles per second. Its surface varies considerably from time to time, as seen through a telescope, and it is consequently concluded that what we see is really a surface of clouds. The great size and small density of Jupiter have led astronomers to believe that it is still in a condition somewhat akin to that of the sun—that is, that it has not yet solidified into a planet like the earth. Its temperature must be very great, though it is not so hot as to give out any perceptible light of its own. The most important marking on its surface is the great red spot which has been visible more or less in the same place since 1878, but no satisfactory explanation of its character has yet been given.

Jupiter has at least seven satellites, four of which are large enough to be seen with a good field-glass, and were among the earliest discoveries made with the telescope of Galileo. The fifth satellite was discovered by the great Lick telescope in 1892, and is very much smaller than the others; the sixth and seventh were discovered by Professor Perrine in 1904-5.

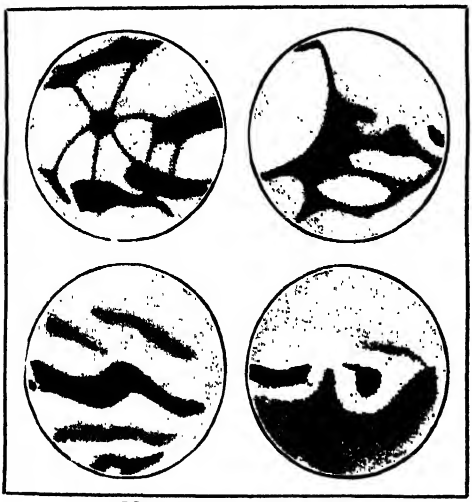
Saturn. Saturn is the outermost of the planets visible to the naked eye, and known to the ancients. Its mean distance from the sun is about nine and a half times that of the earth, or 886,000,000 miles. It is the second largest of the planets, being about 72,500 miles in diameter. Its mass is 95 times that of the earth, and its mean density is only two-thirds that of water, so that the whole planet would float if it could be immersed in a vast ocean; hence, like Jupiter, it is supposed to be still in a largely gaseous condition. Its supply of heat and light from the sun is less than one-ninetieth of that received by the earth, and at its great distance the sun can only appear as a peculiarly brilliant star. Saturn rotates on its axis in about 10 hours 14 minutes, and takes $29\frac{1}{2}$ years to complete its revolution round the sun. Its synodic period of apparent revolution round the earth is 378 days.

Saturn's Rings. Saturn is the most remarkable of the planets, and one of the most beautiful telescopic objects in the heavens, by reason of the wonderful system of *rings* with which it is girdled [33]. When favourably visible from the earth it appears like a globe surrounded by three flat thin concentric rings lying in the plane of its equator. These rings revolve round the planet, and their plane always remains parallel to itself.

It has been proved that the rings are not a solid

structure, but consist of swarms of tiny meteorites, like the shooting stars which occasionally flash into our atmosphere. They must form a wonderfully beautiful spectacle if they could be seen from the surface of the planet which they adorn —a vast arch of light stretching from side to side across the sky and brilliantly illuminated through a great part of the planet's night. In addition to these rings, Saturn has no less than ten satellites, the largest of which is about half the size of the earth. With one exception they revolve in the same plane as the rings.

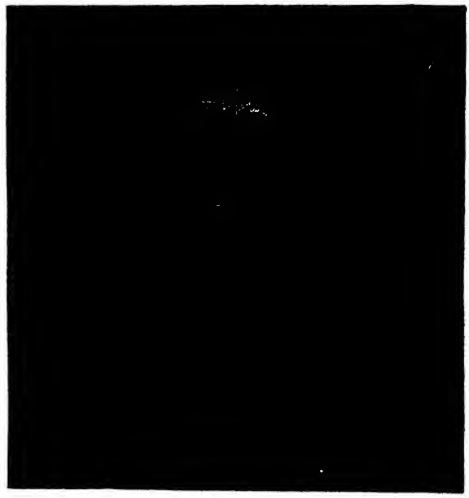
Uranus. The two outermost of the planets were not known to the ancients. Uranus was the first planet discovered in modern times, being found by Sir William Herschel, in 1781. whilst he was sweeping the heavens with a seven-inch reflecting telescope of his own construction. It had frequently been observed before, but had always been mistaken for one of the fixed stars. But when Herschel saw it he recognised by the visible disc which it presented that it must belong to the solar system, and following observations proved that it was a planet lying beyond Saturn. Its mean distance from the



36. DRAWINGS OF MARS
(From "Knowledge," by permission of E. Walter Maunder, F.R.A.S.)

sun is 19·2 times that of the earth, and it completes a revolution in its vast orbit in 84 years. Uranus can occasionally, on a moonless night, be made out by a very keen eye, as a star of the sixth magnitude, and certain early traditions about an eighth planet are supposed to imply that its true nature had thus been perceived by very primitive astronomers. Its mass is about 14·6 times that of the earth, and its density is not quite double that of water. Little is known of its physical constitution; even its diameter has not been measured with any certainty, though it is probably about 30,000 miles. Uranus has four satellites, and possibly faint rings like those which encircle Saturn.

The Discovery of Neptune. The discovery of Uranus was a happy accident, but that of Neptune was the greatest triumph of mathematical astronomy since the time of Newton. After the orbit of Uranus had been fully calculated, it was found that the actual motion of that planet did not quite agree with prediction. It began to stray from its allotted place to an extent which was almost perceptible to the naked eye, and which astronomers consequently had to explain. The only valid



39. A COMET, SHOWING TAILS

explanation was that there must be an unknown planet still further from the sun than Uranus, whose attraction perturbed that planet, and so drew it away from its predicted motions.

Shortly before the middle of the nineteenth century, the problem of determining the place of such a planet from the trivial disturbances which it caused in the motions of Uranus was independently attacked by two astronomers—Adams, of England, and Le Verrier, of France. They both succeeded in solving it about the same time, though it was the calculations of Le Verrier which first enabled Galle's telescope to be pointed to Neptune, in 1846. The discovery of this planet was a remarkable confirmation—if such had been needed—of the truth of Newton's theory of the planetary movements under the law of gravitation.

Neptune. Neptune is quite invisible to the naked eye, though it can just be seen with a good field-glass. Its mean distance from the sun is about 2,800,000,000 miles, and it takes 165 years to complete its orbital revolution. Its diameter is probably about 30,000 miles, and its mass is about

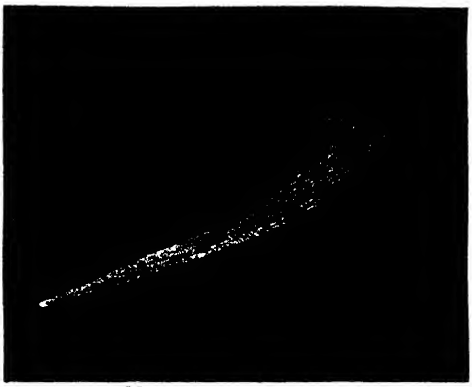
37. TELESCOPIC APPEARANCE OF MARS IN FEBRUARY, 1901 (From "Knowledge")

17 times that of the earth. Its density is about equal to that of Uranus—one-third that of the earth. Nothing is known of its rotation or physical constitution. It lies on the confines of the solar system, and if it were inhabited—which seems impossible—the sun would look to its people no bigger than Venus at her nearest approach to the earth, though the light which it gave would still be equal to that of 700 full moons. Neptune has one satellite, whose motion is even more irregular than that of the satellites of Uranus.

Comets and Meteorites. In addition to the planets and their satellites, the sun is attended by a large number of other bodies, moving with far less regularity, and generally much less conspicuous in the heavens. These are known as *comets* and *meteorites* or *shooting stars*. One of the most interesting of recent astronomical discoveries is that an intimate physical connection exists between these two classes of bodies.

Comets. Comets have been known from the earliest times, because every now and then a very large and conspicuous one hastens up to the sun from the remote regions of space, and perplexes monarchs with the fear of change. They are called *comets*, from the Latin *coma*, meaning hair, because when they are bright enough to be seen with the naked eye they look like stars attended by a long stream of hazy light, which was thought to resemble a woman's hair flowing down her back [35]. This train of light is known as the comet's *tail*. Such bright comets, of which the last visible in our latitudes made its appearance in 1893, are sometimes as brilliant as Venus; their tails have been known to stretch halfway across the visible sky.

These comets are very beautiful and conspicuous objects, which usually appear in the sky without any warning from astronomers, and invariably create a great popular sensation [38]. By far the greatest number of comets, however, are only visible through a telescope, and it is rare that a year passes without at least half a dozen of these being reported. Up to the present time nearly a thousand comets of all sizes have been recorded. Not more than one in five of these is visible to the naked eye.


38. THE COMET OF 1882

Cometary Orbits. In all cases in which a comet has been observed sufficiently often for its orbit to be calculated, it is found that it moves in one of the curves which are known to the geometer as conic sections. Less than a hundred of the known comets move like the planets in *elliptical* orbits, and consequently their periodical return to visibility can be predicted. As a rule, the eccentricity of these cometary orbits is very much greater than that of any planetary orbit, which means that the comet approaches fairly close to the sun at one end of its orbit, but at the other flies away far beyond the outermost planet, and for a long period disappears from the ken of our most powerful telescopes.

The great majority of comets have only been seen once, and their orbits appear to be either *parabolic* or *hyperbolic*. Neither of these is a closed curve, and what seems to happen in such cases is that a comet travelling in such an orbit dashes up to the sun from the remote parts of space, swings round it, often at very close quarters, and flies away again for ever [34]. Only those comets which have elliptical orbits can be said to belong to the solar system. The others are visitors from space, which in the course of their motion come near the sun and are deflected by it, but then fly away until after a lapse of ages they perhaps come within the sphere of another star's attraction. Of the comets which move in elliptical orbits, about twenty have been observed at more than one return to the sun. Some of these complete their orbits in quite a short period, like Encke's comet, which has the shortest period of all, less than three and a half years; the longest periodical comet is known as Halley's, which returns to the sun after 76 years and is due again about 1910; it is a bright and conspicuous object.

The Constitution of Comets. The nature of comets was long in doubt, and even to-day their physical characteristics are not fully understood. They are certainly formed of gravitational matter, since they move in orbits which are subject to the same laws as those of the planets. But they also appear to be acted upon by powerful *repulsive forces* emanating from the sun, to which is due the remarkable phenomenon of cometary tails. At first it was supposed that a comet and its tail consisted of what we know as solid matter. But the observed facts are quite inconsistent with this theory.

A comet's tail, which stretches for many millions of miles, is always directed away from the sun, and when the comet swings rapidly round the sun the whole of this tail follows its motion in such a way that it is quite impossible to suppose that it consists of any kind of matter with which we are acquainted. The probability is that these tails consist of highly rarefied matter thrown off from the comet under the influence of a repulsive force emanating from the sun which is probably electrical in its nature. The degree of rarefaction of the matter composing these tails is probably greater than that of any vacuum which we can produce in our laboratories, and its luminosity is due to similar causes to those which produce the glow in a vacuum tube through which an electric current is passed. The extreme tenuity of comets is proved by various facts, such as that the earth is known to have passed right through the tail of a comet without any apparent effect, that the close approach of a comet to a planet causes no apparent alteration of the planet's motion, and that small stars can be seen shining brightly right through a comet as much as 100,000 miles in diameter. Perhaps there is not much exaggeration in the statement once made by a well-known astronomer that the whole material of a comet stretching halfway across the visible heavens, if properly compressed, could be packed in a hatbox. The old fear that the earth might suddenly be annihilated by a comet striking it is throughly dispelled by modern investigation, which leads us to believe that the worst results of such an encounter would be an extremely beautiful display of shooting stars.

Continued

COATING & COLOURING METALS

The Processes of Protecting Metals. Corrosion. Coating for Ship Bottoms. Painting, Enamelling, Bronzing, Barffing, and Nickel Plating

Continued from page 6460

METALS are coated for two reasons—to prevent gradual destruction by corrosion and for purposes of ornament. Usually both reasons operate, and, consistent with the proper protection from corrosive influences, appearance is usually given the deciding voice. Some processes of protecting metals, including galvanising [page 6168] and tinning [page 6164], have already been described in detail, and we shall therefore ignore them in the present consideration. We shall notice briefly the fundamental facts regarding the other processes; and we shall consider first the protection of iron and steel by painting when protection and not appearance is the object sought.

Corrosion. Iron has an affinity for oxygen, and the result is oxide of iron, which we know as rust. Moisture accelerates the formation of rust, and precautions must be taken to avoid this. In protecting beams which are embedded in masonry lime is used to advantage, and we consider this and some other methods of treating structural steel work further on. Asphalt is the most satisfactory coating for such situations. The asphalt used should be naturally soft or may be made soft by reducing a hard asphalt with a heavy mineral oil.

For cast-iron water pipes the common protection is a coating of Dr. Angus Smith's solution [see page 5320]; but the process does not give satisfactory results with steel pipes, chiefly because steel pipes are thinner and do not retain long enough the heat necessary to cause Angus Smith's solution to form a hard, impenetrable film upon the surface. Steel pipes are best coated with asphaltum reduced to an elastic varnish by the use of oil, and baked on hard in an oven. On a large scale the work is performed most economically by dipping, the dipping tank being of a form to suit the work.

Painting Iron and Steel. Iron oxide and metallic brown paints should never be used with iron and steel. Such paints are merely iron in a more or less advanced stage of oxidation; in other words, rust. Rust promotes rust. Iron oxide, even in the form of paint, conveys oxygen from moist atmosphere to the metal, and becomes a vehicle for the spread of rust. Zinc oxide paints also are found to peel off, and salvation is found in oxide of lead paints. Red lead forms with linseed oil a hard elastic coating that adheres to the metal surface with great tenacity. Its only chemical effect is to promote the formation of black or magnetic oxide, that prevents corrosion and does not act as a communicating medium for atmospheric oxygen. Red lead in oil "sets" much as plaster of Paris sets when mixed with water; and just as plaster of Paris cannot be worked to advantage after it has partly set, so a red lead paint should not be applied when the process of setting has progressed some way. The usual practice in large shipyards—these may be selected because the work in them demands the best-known practice—is that the red lead is mixed with just enough linseed oil to form a stiff, tough paste, which will keep for several days without hardening. This paste, when required for use, is thinned down with a proper proportion of pure linseed oil and applied at once, care being taken to leave no paint in the pots overnight. By this method the lead and oil "set" on the surface of the metal, and the adhesion is thereby more tenacious than it would be otherwise. The best mixture is 5 lb. of pure linseed oil and 18 lb. of red lead, which make one gallon of paint, and can be made to cover 500 square feet as a first coat, or 600 square feet as a second coat.

The advantages of red lead as a paint for iron and steel are that it dries easily with raw linseed oil without the need for the addition of any "drier," that after it has dried it forms an elastic coat capable of expansion and contraction with the metal, that it does not impart or convey oxygen to the surface upon which it rests, and that it hardens without shrivelling, making a tough and insoluble covering.

All varieties of driers impair the value of any paint applied to iron and steel. The nature of all driers is acid, and any acid will ultimately induce corrosion or oxidation of any iron surface to which it is applied, thereby lessening the stability and protective properties of the applied coating.

Corrosion by Sea Water. Industrially, no process of coating metals is more important than when the objects coated have to withstand the action of sea-water. Utility is the first consideration, and artistic effect, while not negligible, is of much less importance. A few years ago extended tests were made upon steel and aluminium plates in Brooklyn Navy Yard, under the care of scientific authorities, in order to determine the most satisfactory coating to resist sea-water corrosion. Seventy-two plates were immersed in the sea and withdrawn. Sixty of them were left for thirteen months, and twelve of them were subjected to nineteen months' immersion. A careful examination of them after withdrawal was instructive, and led to certain definite conclusions, which may be summarised as follows: Whatever pigment is used for sea work, a more durable coating results if varnish is the vehicle than if oil be used. Further, a varnish coating, or a pigment and varnish coating, withstands sea-water action better when baked on than it does when only air dried. Zinc-white was found to be more durable than any other pigment used in the test, and finally enamel coatings, baked on at high temperatures, were proved more durable than any other coating.

Anti-fouling Paints. In the old days of wooden ships, the hulls used to be sheathed in copper to give anti-fouling properties, but when iron and steel plates superseded wood for shipbuilding purposes, copper had to be discarded. When a plate of iron or steel and another of copper are joined or in mechanical contact in any acidulated solution of water, such as sea-water, the iron becomes electro-positive to the copper, and corrodes rapidly. The value of copper lay in the fact that it protected the wood beneath it from the action of sea-water, and because it constituted a substance with anti-fouling properties; that is to say, that marine organisms did not readily attach themselves to it. The anti-fouling paints or compositions now used are legion. Many of them are secret preparations,

and others are the subject of letters patent. Most of them are sold under proprietary names.

The essentials in a paint for ships' bottoms are that it must be of a nature capable of protecting the surface of the hull from corrosive influences; it must form a smooth surface, so as to offer as little friction to the water as possible; and it must be a rapid dryer, so that the bottom may be cleaned and two coats of paint applied in one day. The compositions used must be adapted to the waters through which the ship has to make her way. For instance, the waters of the Indian Ocean are more fouling than those of the Atlantic, and a composition for use in the former ought to have a higher percentage of a poisonous ingredient. The harder the paint on a ship bottom, the longer it will last. The use of shellac dissolved in spirit gives a coating of the necessary hardness and adhesive powers. The second or external coating should contain a poisonous ingredient that will kill the marine organisms seeking to adhere to the hull surface. Zinc-white, arsenic, copper, and quicksilver have all their use in different compositions. The more scaly the composition the more frequently must it be renewed. In spite of this scaling, such compositions are usually preferred, because as they scale they carry away with them any attached organisms.

Before applying a ship paint, the surface to be treated must be cleaned. All rust must be removed. Better results are attained by a poor paint on a well-prepared surface, than by a good paint on a badly prepared surface. Among the patented anti-fouling compositions we may mention the following:

1. Bitumen, lime, fine sand or Portland cement, and flaky mica—melted together and applied hot.

2. Mix 32 parts of quicksilver with 1 part sulphurised oil of turpentine by grinding in a mortar; add 60 parts of lard and mutton tallow, working the whole into a homogeneous mass. Finally, add 20 parts of litharge which has been ground up in oil. Before using, reduce to proper consistency by stirring in gradually linseed oil, varnish, and 3 per cent. of peroxide of manganese. Any pigment may be introduced to colour any desired shade. This composition is said to be an effective deterrent to the lodgment of barnacles.

3. Tallow, 40 parts; resin, 10 parts; nitreous sand, 10 parts; arsenic, 1 part. Melt together, and mix well.

Celluloid promises to be a valuable coating material for ship hulls [see under DYEING], when the prejudice against it has been dispelled.

Protecting Structural Steel. Apart from shipbuilding work, there are many purposes for which iron and steel must have a thoroughly protective coat of paint. An important field is for structural steel buildings, which are common in other countries, and which are bound to b come common in this country whenever the restrictive building laws which prevail with us have been modified so as to make the form of construction economically possible. In structural steel work, the steel joists are almost invariably embedded in cement, or covered with wood, stone, or plaster, so that it is impossible to give them periodical coats of paint as may be done with, say, a bridge or a ship's hull. Hence the need at the time of building to make the pigment covering as durable, as impenetrable, and as free from any agent of corrosion as can possibly be done. The extent to which steel-frame buildings can maintain their strength under different methods of protection has for years been a matter of conjecture and theory. The method of construction is not old enough to furnish precise data regarding corrosion under different condition. Hence peculiar value attaches to the examination of buildings which suffered by the San Francisco earthquake and fire last year.

Lessons from San Francisco. San Francisco was a city with many steel-frame buildings, and the new San Francisco will follow this method of construction almost exclusively. From the point of view of investigation, the building which attracted most attention when the ruins came to be examined was a nine-storey insurance office, which was erected in 1893, and had therefore done thirteen years of duty. The rust or freedom from rust of the members of the steel framework after thirteen years of use was the point upon which precise information was sought by architects and others. There was very little rust indeed when the steelwork was exposed. Where the steel was covered with lime only, there was found to be a little more rust than when Portland cement and lime had been used together. Where there was rust under the paint, it is thought that care was not exercised in having the surface clean at the time of painting. But, generally speaking, the freedom from rust was so general, and the condition of the members so satisfactory, that all the columns, beams, tie rods, and bolts were sold for use in new buildings in the vicinity.

From the whole experience certain conclusions are drawn regarding steel-frame buildings, and some of these considerations are briefly as follows:

A steel frame, properly painted and buried in masonry, will not rust enough in thirteen years to affect its strength appreciably. The better the steel is coated with mortar, the less it will rust. Portland cement is better than lime mortar for imbedding steel to prevent it from rusting. Unpainted iron rods buried in mortar composed of lime and a large proportion of Portland cement rust very little—certainly not enough to impair their strength. If steel is not thoroughly cleaned before it is painted, the paint will not greatly retard the progress of rust. It is much easier to cover steel thoroughly with concrete than with brick masonry. If brick masonry is to be used, the bricklayer should plaster the steel thoroughly before the brickwork is put up. The quality of paint used, though important, is not so important as surrounding every part of the steel with Portland cement. Cinder concrete does not injure to the slightest degree a steel floor-beam that has been painted.

Paint for Tin and Zinc. In this country tin is not used as a roofing material. But in other countries—conspicuously in Canada—tinplate is an exceedingly common roofing material. A common paint for tin roofs, when they are treated with paint, is made by mixing Venetian red, Spanish brown, or yellow ochre—or these in combination according to the colour desired—with pure raw linseed oil. Such a paint attains a great elasticity, which enables it to expand and contract with the metal without cracking. As tin roofs are generally used only in countries subject to wide extremes of temperature, this property is valuable.

It is extremely difficult to persuade oil colours to adhere to zinc owing to the coating of zinc oxide. But zinc seldom needs painting for protection, as it does not corrode under atmospheric exposure. By means of a special treatment zinc is said to be made capable of taking on an oil paint satisfactorily.

This treatment consists in the application of a mordant made by dissolving 1 part each of chloride of copper, nitrate of copper, and sal ammoniac in 64 parts of water, and thereafter adding 1 part of hydrochloric acid. Under this treatment the zinc first becomes a deep black, but during the drying process this changes to a grey, to which oil colours will adhere satisfactorily.

Cleaning Metals. No matter what process of covering metals is to be adopted, it is essential that the article to be coated should be cleaned if good is to result. There is no exception to the rule. Rust, dirt or grease prevent intimate adhesion, no matter whether the coating be paint, enamel, or another metal to be deposited by simple immersion or by electric deposition. The methods employed for cleaning iron and other metals before galvanising and tinning have been considered on pages 6164 and 6169, and, generally speaking, those methods apply to all metals upon which a fine finish is desired.

The usual method of cleaning for good work is by *pickling* or immersion in an acid bath, and the usual pickle is sulphuric acid and water (1 in 20 to 1 in 30). Where sand has to be removed, as with cast iron sometimes, hydrofluoric acid is better as it dissolves the sand (silica) and is not active upon the metal. After pickling, the work must be washed well with water so as to remove any trace of acid. Where the article is greasy, a solution of caustic soda or of caustic potash in water is the best means of removing the grease. It is best applied hot. When rust has to be removed from iron or steel a good mixture to use is made by mixing 1 part of hydrochloric acid and 6 parts of sulphuric acid in 1 gallon of water; then when the rust has been removed another bath made by dissolving 4 oz. of zinc sulphate in 1 gallon of water and by adding 16 oz. of sulphuric acid completes the cleaning process. Corroded brass or copper is best cleaned by dipping it into a mixture containing 3 parts of nitric acid, 6 parts of sulphuric acid, and 8 parts of water. Corroded zinc may be cleaned by dipping into an acid bath with 1 part of sulphuric acid, 2 parts of hydrochloric acid, and 160 parts of water. For dirty lead, tin, and pewter a hot caustic soda solution is best.

Polishing Metals. For work of a high order such as enamelling and plating the mere removal of rust and grease is not enough. It must be polished if the resulting surface is to be excellent. There are many methods of polishing. Sand blasting we have described elsewhere [see page 6314]. It is used chiefly for brass and other soft alloys. Other processes are stone and emery grinding, scratchbrushing, and buffing. The methods adopted depend upon the condition and nature of the work and upon the finish desired. Preliminary processes where the surface is coarse consist of grinding upon an emery or corundum wheel [see page 6314]. For finer work polishing lathes are used. These have circular wire brushes, hair brushes, leather bobs, felt bobs, or cotton bobs revolving at high speed. Wire brushes are usually lubricated with some liquid such as stale beer, the object being to keep the brush from becoming too hot and to prevent it from cutting into the metal. With the other forms of brushes or bobs, polishing powders or polishing compositions are used. The usual best practice is to have the polishing material in the form of a cake and to apply it to the bob simply by holding it in contact as the latter revolves. The materials are composed of rottenstone, pumicestone, emery in various degrees of fineness, crocus, tripoli powder, and rouge. Tripoli is used coarse, for instance, for brasswork and small iron and steel, while if the work is to be plated fine tripoli and crocus are used. Rouge is used for finer work still—for cutlery and jewellery. Any of these compositions and materials can be used with hand polishing brushes and tools, but this practice is laborious and costly, hence seldom used in manufacturing industries.

Bluing Iron and Steel by Heat. Small articles of polished iron or steel may be blued easily by the use of heat. The most convenient method of applying this heat is by the agency of a Bunsen burner, which yields a hot flame but does not smoke. Another common method, especially for flat work, is to heat a flat piece of iron and steel—sufficiently thick to retain its heat for a long time—and to place the small objects upon its hot surface in direct contact or upon a piece of sheet iron interposed between the two. The Bunsen burner, when properly constructed, should burn with a light blue flame, having within it a blue-green flame, the apex of which is the point of most intense heat. The article being heated should be held immediately above this point of greatest heat. Watch the change in colour as the iron or steel article rises in temperature under the heat. Withdraw it from the flame before it quite comes to the desired shade of blue, hold it in the air until the desired tone appears, and at this point throw the article into oil—preferably a heavy oil, such as fish oil or lard oil—where it may be allowed to cool. When the article being treated is of uniform shape, the work is easy; but where the shape is irregular—say, thick at one part and thin at another part—greater care and practice is necessary to secure uniform results. In such a case the heat must be confined to the thicker part for a longer time than is necessary for the small parts. Another method of attaining the same result is to heat sand very hot in a pan, then to immerse the articles in the sand, and to roll them around until the desired shade appears, when the colour is fixed by the oil-bath, as already stated. By all of these methods the iron or steel passes through the following colours—pale straw, dark straw, brown, purple, blue and green, as its heat increases, and it may be arrested at any one of them.

Of the many other recipes recommended for bluing iron and steel, the following may be put on record: A solution of 1 oz. lead acetate and 1 oz. sodium thiosulphate in 50 fluid ounces of water, being used hot, imparts tones from a light brown bronze to black, according to the duration of the soaking, the intermediate tints being purple, blue, light blue, and steel grey.

Lacquering. Metals may be lacquered both to preserve them from atmospheric action and to improve the appearance. The usual transparent lacquer is made by dissolving shellac in methylated spirit and colouring matter such as dragon's blood for red, and gamboge or turmeric for yellow, while a wide range of colours is secured by introducing the aniline dyes. In applying the lacquer the article being treated should be kept warm at a uniform temperature. The work should be done where there is no dust floating about, and the operation should be performed rapidly and smoothly. The lacquers should be kept in stoppered bottles, which are best when of opaque glass. They should be applied with a thin, wide and flat brush. [See Graham's table of lacquers on the following page.]

Enamelling. Enamelling is perhaps the most common of the processes of coating small articles of iron and steel. We refer not to the vitreous enamelling such as is found on the enamelled milk saucepan and the enamelled mug, but to the ordinary enamel paints which are applied either by a brush or by dipping and afterwards hardened in an enamelling stove. Articles enamelled in this way are found in every household—the iron bedstead, the coal-scuttle, the room fender, and many other articles of domestic use. This sort of enamel is merely a fine paint, which is dried and hardened by heat.

COMPOSITION OF LACQUERS.

Number.	Shellac.	Mastic.	Canada balsam.	Spirits of wine.	Pyro-acetic ether.	Spirits of turpentine.	Turpentine varnish.	Simple pale lacquer.	Dragon's blood.	Annotto.	Saunders.	Turmeric.	Gamboge.	Saffron.	Cape Aloes.	Sandarac.	
	oz.	dr.	dr.	pt.	oz.	dr.	oz.	pt.	dr.	dr.	gr.	dr.	dr.	dr.	dr.	dr.	
1	4	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	Strong simple.
2	1	—	—	1	—	—	—	—	—	—	—	—	—	—	—	—	Simple pale.
3	1	—	—	1	—	—	—	—	—	—	—	—	1	—	3	—	Fine pale.
4	1	—	—	1	—	—	—	—	—	—	—	1	1	2	—	—	"
5	1	—	—	2	—	—	—	—	1	1	—	—	16	4	—	8	"
6	2	—	—	2	—	—	—	—	1	8	—	32	—	—	—	8	Plate gold.
7	2	—	—	1	—	—	—	—	—	—	—	—	2	—	4	—	Pale yellow.
8	5	—	—	3	80	—	—	—	—	—	—	—	—	—	—	—	"
9	—	—	—	—	—	—	—	1	—	1	—	4	—	—	—	—	Full yellow.
10	3	—	—	1	—	—	—	—	—	2	—	16	—	2	—	—	Gold.
11	3	—	—	4	—	—	6	—	—	—	—	64	6	—	—	14	"
12	1	—	—	1	—	—	—	—	—	—	—	20	—	—	2	6	"
13	3	—	—	1	—	—	—	—	4	—	—	16	—	—	—	—	Deep gold.
14	3	—	—	1	—	—	—	—	4	—	—	1	—	—	—	—	"
15	3	—	—	1	—	30	—	—	40	—	12	10	—	—	—	—	"
16	—	—	—	—	—	—	—	1	8	33	—	—	—	—	—	—	Red.
17	1	—	—	—	—	—	1	—	8	24	—	—	—	—	—	27	"
18	15	30	30	6	—	—	—	—	20	—	—	60	—	10	—	—	Tin lacquer.
19	—	—	—	—	—	—	—	1	—	—	—	4	1	—	—	—	Green, for bronze.

The Enamelling Stove. An enamelling stove is necessary for the work. It is best heated by Bunsen burners. Enamelling stoves may be purchased from makers who specialise in them, but any ironplate worker can make one without difficulty, and if proper precautions be taken, the home-made article is often better than the factory stove. A ventilator at the top permits a current of hot air to circulate through the stove. It is an economical provision to have the walls lined with a non-conducting material, such as fireclay, so as to prevent unnecessary heat radiation, thereby reducing the amount of gas consumed to maintain the proper heat. The sides should be fitted with angle iron bars upon which bars or shelves may rest to support the work. The door should be made the whole width of the front, thus permitting easy ingress and egress of the articles before and after enamelling. It should also have fixed to its inner side a thermometer registering up to not less than 400° F., and capable of being inspected from the outside. The usual device is to have an oblong panel cut from the door in front of the thermometer and fitted with a sliding or swinging cover which can be removed when it is desired to read the temperature. The gas supply should be in excess of requirements so that the proper heat can always be secured. The heat is regulated by raising or lowering the gas jets or by lighting or extinguishing one of the Bunsen tubes.

For many purposes—a cycle frame, for instance, or a fine cast-iron stove—a fine polish is essential. The finer the polish the finer is the resulting coat of enamel. The polish is obtained first by grinding on a grindstone, or an emery wheel if the work be rough. For work that is not rough originally, polishing with a fine emery bob and then with a leather and cloth bob is sufficient. Some work is "sweated" before having the coating of enamel applied—that is, rubbed with a cloth wrung out of spirits of tar and placed in the stove at full heat of, say, 300° F. to 400° F. for a quarter of an hour

The Coats of Enamel. Some articles may have only one coat of enamel, in which case the finishing enamel is that applied, but in most cases a first coating precedes the finishing coat. The article is either painted with the enamel by means of a brush, or dipped into a bath or trough containing enamel. If the brush be used, it must be of good quality so as to lessen the likelihood of hairs adhering to the surface. A hair cannot be removed after the enamel has been hardened without leaving a blemish. The size and shape of the trough, if dipping be practised, must be decided by the shape of the articles, but a trough is used only where enamelling is on a large scale.

The enamels are purchased from firms making a speciality of their preparation. The enameller need not think of making them for himself. The work having received its first coating, is placed in the stove, and is given the necessary heat for a period depending on the colour and quality of the enamel. For black enamel the heat is usually from 300° F. to 350° F., and for coloured enamels about 125° to 150°. Care should be taken not to give the full heat at once. The time required at this heat is usually between one and two hours, and must be decided by experience. Keeping the work in the full heat for too long a time makes the enamel easily chipped besides consuming unnecessary gas. When the gas is turned off the enamel is hot, but wet. When it has dried the article is polished with a paste made of pumicestone in an impalpable powder or crocus and water. All roughness should be carefully removed in this polishing.

The finishing coat—not of the enamel formerly used, but of "finishing enamel"—is then given. It must be applied in a thin coat or the finished appearance will be blotchy and shrivelled. The work is again put into the stove and the full heat maintained until it is slightly "tacky" or "gummy" when touched. Then turn out the gas and allow the article to cool. The article is enamelled. If a still higher degree of finish be desired, this second coat may be rubbed smooth with the paste as before, and a third coat—another of the second or finishing coat—applied, but this is seldom done.

The enamels should always be kept corked when not in use, so as to prevent dust or other extraneous matter getting into them. As much work as possible should be put into the stove at each heating, thereby diminishing the cost of gas upon each article.

Vitreous Enamelling. The process of applying a coating of vitreous enamel to articles of metal has during the last few decades spread from the field of ornament into that of utility, and an enormous industry, which flourishes especially in Germany and Austria, has grown into being. Street signs, and culinary and domestic utensils are the articles to which vitreous enamel is most frequently applied. In Continental Europe cast-iron work, such as coal stoves, is treated to this variety of enamelling, but in this country its use in this direction is limited.

Enamel is merely a coating of a glass applied with an ingredient such as tin oxide or bone ash to render the glass opaque. Into coloured enamels other ingredients are introduced, in accordance with the colour desired. White is by far the most common variety of enamel used for coating articles of metal, and blue comes second in importance. In America, however, mottled or "granite" ware is more common than white. A knowledge of the properties and composition of glass is essential to the manufacturer of enamels, and reference may be made to the article on glass manufacture [page 4531].

A *flux* is necessary to cause the enamel to adhere to the surface of the metal. Borax is the flux at once the most easy to work and that most generally employed. Other fluxes are fluorspar, broken glass or *cullet*, gypsum, clay, and broken porcelain. These fluxes are used alone or in various combinations according to the class of work under treatment.

To introduce colour into enamel many metallic oxides are used. The chief pigments in general use are as follows:

To give blue—Cobalt oxide and cobalt silicate.
,, black—Ferrous oxide.
,, brown—Ferric oxide.
,, green—Ferrous oxide (in small quantities), cupric oxide or chromic oxide.
,, red—Ferric aluminate, tin-gold chloride, sodium-gold chloride or purple of Cassius.
,, yellow—Oxides of silver, iron, uranium, and antimony or antimonate of potassium or lead.
,, violet—Oxide of manganese.

Lead in Enamels. Lead ought to be absent from enamel applied to any vessel intended to contain food. On account of the affinity of lead for silica a lead enamel is an easy one to manipulate, and makers of cheap enamel ware use it extensively. But it cannot be too strongly urged that its use is dangerous. The presence of lead in the enamel of an article may be detected by several simple methods. If weak vinegar be boiled in an enamelled vessel, and if as a result the surface of the enamel becomes dull and rough, lead is present. This test will also throw lead into solution in the vinegar. Another test is to beat up an egg in an enamelled vessel, and allow it to stand for twenty-four hours. The sulphuretted hydrogen in the egg will darken the lead oxide and cause the enamel to show a stain. For most pieces of chemical apparatus also an enamel containing oxide of lead is bad, as the lead may enter into chemical combination and vitiate or modify the results attained. There are many recipes for leadless enamels. Mr. Paul Randau vouches for one as being in use in some large Austrian enamel works, and we give the formula:

Silica	30 to 50 parts
Flint	10 ,, 20 ,,
Kaolin	10 ,, 20 ,,
Pipeclay	8 ,, 16 ,,
Chalk	6 ,, 10 ,,
Ground porcelain	5 ,, 15 ,,
Boric acid	20 ,, 40 ,,
Saltpetre	6 ,, 10 ,,
Gypsum	2 ,, 5 ,,

Enamel adheres better to charcoal iron than to coke iron, and in cast iron to "wh te iron" rather than to "grey iron." White iron, however, is rather hard and brittle for most purposes to which enamelled iron is put, hence a mixture of white and grey pigs are generally used in cast iron that has to be enamelled.

Preparation for Enamelling. To prepare iron and steel for the coating of enamel, they must be pickled in diluted acid, a process which has been described in some detail in our descriptions of galvanising and tinning [see pages 6164 and 6169]. If greasy, treatment with caustic soda removes the grease. The articles are then scoured with clean, sharp sand until quite bright. Many mechanical devices are adopted to secure economy of work and big output in large works, but we shall not stay to consider these devices here. A common one is a sand blast apparatus. After scouring, the work is dipped into boiling water, drying immediately after withdrawal, when it is ready for the enamel coating.

The under coat is then applied. The enamel is usually kept moist, and is therefore like clinging sand. Before application, it is reduced with water to the consistency of cream. The workman ladles into the vessel, the interior of which is to be enamelled, as much of this enamel cream as experience teaches him will suffice for the work, and by means of a stiff brush he spreads it over the surface to be coated. Any excess is allowed to drip off, but practice enables the workman to dispense with the necessity of draining. The work coated with this enamel is then taken into the drying-room, preferably heated by steam pipes, and after remaining there about one hour, the article is dry and ready for fi ing, for which purpose it is taken to the muffle furnace.

The muffle furnace is of the ordinary type, and must be of a capacity to suit the work. But workshop economy demands that it should be made quite full every time it is heated, hence there is danger of expense in having the furnace too large. It is better to increase the number rather than to increase the size of the furnaces; but there must always be one large enough to accommodate the largest piece of work likely to be treated. The fuel for the furnace may be that most convenient to the district. Gas may be chosen with advantage, if it be available, as it allows the temperature to be regulated perfectly.

Firing the Enamel. The object of the muffle forms of furnace is, of course, that the contents may come under the full heat given off, but may yet be secure from the dust and smoke that would surround them if there were no muffle. It is usual to have the greatest heat at the back of the muffle, so that the articles are not subject to the extreme heat immediately after insertion. The work is put into the muffle when the front of the latter is at a dull red heat, and the back portion at a bright red heat. The pieces of work are moved about by the workman into the hotter or cooler portions as they seem to require it. One expert man can attend to a round dozen of muffles, filled with work. From twenty minutes to half an hour ought to suffice for this firing. After that time, the enamel will have fused over and on to the metal. It will still have the powdery effect which it had when it entered the furnace, but the powder can no longer be rubbed off with the finger, and close examination will show that the adhering particles have lost their sharp edges. If the powder does not adhere well in the manner indicated, the enamel composition is too refractory, and must have some borax stirred into it. If, on the other hand, it be very smooth on its surface, it is too fusible, and the enamel mass must have some clay or flint added to it to make it more refractory.

The Final Coat. The covering coat is applied after the article has been withdrawn. If there be any exposed iron which was not intended to be enamelled, and was therefore not coated with enamel composition in the first instance, the firing will have made it black. This black, which is black oxide of iron, must be removed with wire brushes. The finishing layer of enamel is now applied in the same manner as the first was. The thinner it can be made, consistent with efficient covering, the higher will be the finish and the greater the durability of the finished article. The temperature of the muffle furnace for the finishing coat is kept a little lower than it was for the first layer, as the composition is more easily fusible. Also the articles are moved about in the muffle,

and turned more frequently, so as to secure uniformity in the process of fusion. When it is considered that they have had enough of the fire, they are removed, but ought to be allowed to cool gradually, otherwise the enamel may crack in the cooling. There is frequently a separate muffle at a dull red heat, into which the articles are placed and allowed to cool slowly. The enamelling is now complete.

Cheap enamel ware is frequently made with only one coating of enamel, but good work that will stand the test of use, especially if it be for articles for cooking, demand two coats. The first, or ground coating, should be somewhat porous, and the upper or covering layer forms the impenetrable glaze.

Decorating Enamel Ware. The common method of decorating enamel ware is by means of transfers as used for pottery ware. The ink with which these transfers are printed must be made of fusible oxides. To fix a transfer to an enamel surface is not difficult. It is applied, the back of the transfer is damped with a sponge, and the article is fired, so as to fix the ornamentation. Hand decoration is also practised, and is the common method when bands are being put on the outside of vessels, but for elaborate work its cost is prohibitive. Mottled or *granite* enamel ware is made by spraying upon a coating of white or yellow enamel a covering, or rather a partial covering, of coloured enamel. It is then fired in the usual way, and if a good surface be desired, it is treated with a final transparent enamel glaze.

Colouring Metals. The numerous processes for bronzing metals may be divided into three classes, depending for their action upon chemical change, electro-chemical change, and mechanical application. The first and the second might properly be classed as one, but electric deposition is such an important and such a distinct process, that it may well be elevated into a class apart.

All metal articles may be treated to an application of bronze powder, caused to adhere to the surface of the metal by a special varnish. Bronze powders are made in dozens—indeed, hundreds—of shades, and their manufacture is a huge industry in Austria, which supplies the greater part of the world with them. The so-called *bronze* powder is simply metallic brass, copper, aluminium, or other metal or alloy in a very fine state of subdivision. The particular depth of shade is usually obtained by oxidising more or less the metal in the manufacture of bronze, but with this, the man who applies the powder has no direct concern. [See also page 6310.]

The article to be bronzed is usually coated with a special varnish. This varnish, or *size*, had better be purchased from varnish manufacturers, but a good recipe for its manufacture is as follows: Boil linseed oil for two hours, and add to it gradually, when boiling, 5 per cent. of its weight of red litharge, followed by 5 per cent. of white litharge. If the first addition of red lead cause the formation of a red scum, the oil is at too high a temperature, and the further addition of red lead must be delayed until the oil has cooled somewhat. The mixture is kept for about a week, and is then ready for use.

The iron or other article to be bronze-coated is given a coat with the varnish or size, and when this varnish has become almost dry, or, as it is called, *tacky*, the bronze powder is applied, usually with a brush. Then, when the varnish has quite dried, the surplus powder is brushed off and the article is bronzed. It may be coated with varnish again, and will, after this precaution, resist atmospheric action and retain its freshness much longer than it otherwise would. It must not be forgotten, however, that any varnish applied after the bronze powder diminishes the metallic brightness, so that the manipulator must choose between brilliance and durability.

An expeditious, economical, and satisfactory method of applying bronze powder is by mixing it up like ordinary paint, with the varnish as a base, and by painting it on the surface to be decorated. Two coats are desirable, and, of course, these may be thinner than a one-coat application. Turpentine is the medium used to thin the varnish. The hardness and durability of the bronze coating is much increased if the article be dried in a japanning stove. The temperature should not be high—not more than 200° or 250°—and half an hour is about long enough time to allow.

Bronzing Brass by Immersion. There are many simple immersion baths used to bronze metals, and the tone resulting depends upon the duration of the immersion. Brass may be coloured any shade from brown to black by a bath made by dissolving 2½ oz. of nitrate or perchloride of iron in 1 gal. of water. Any shade from brown to red may be secured by immersion in a solution containing ½ lb. nitrate of iron and hyposulphite of soda in 1 gal. of water. Yellow to red demands a bath where ¼ oz. tersulphide of arsenic, and 3 oz. of pearlash solution have been dissolved in 1 gal. of water. Potassium sulphide added to water (½ oz. to 1 gal.) gives orange bronze; a mixture of perchloride of iron and water (1 gal. to 2 gal.) gives an olive green, while sulphocyanide of potassium (20 oz.) and water (1 gal.) gives a blue.

Bronzing Copper by Immersion. Bronzing copper baths, used simply by immersing the copper articles in the solutions, are as follows, the chemicals mentioned being dissolved in 1 gal. of water:

Brown to black, 2½ oz. nitrate of iron.

Dark drab, 2½ oz. nitrate of iron and 1 oz. sulphocyanide of potassium.

Bright red, 1 oz. sulphide of antimony and ½ lb. pearlash.

Red to black, ½ oz. sulphur and 1 lb. pearlash.

Steel grey, ½ oz. chloride of arsenic (must be applied at 180° F.).

Japanese Lacquer. Japanese lacquer is valuable as a metal coating, and when once the secret of its manufacture has been given to the Western world, its use will extend. But at present its precise method of preparation is held as a jealous secret. It is known to be made from the secretion of a tree, the *Rhus vermicifera*, called by the Japanese the *urushi-naki*, which grows to a height of about 30 ft. when it attains its full yielding capacity. The lac is collected by making horizontal incisions in the tree. The issuing lac is milky white and thick, but on exposure becomes first dark brown, and finally black. The lac is purified by being strained through cotton-wool, then by rubbing it on a paint slab and mixing it well with water, which is finally evaporated by heat. The further treatment in preparing the famous Japanese lac varnishes is not known outside of Japan. White and pure light colours cannot be obtained in these Japanese lacquer varnishes. The usual colours are brilliant black, impure vermilion, impure dark green, and dark grey. Drying is done in twenty-four hours in a moist atmosphere, and if the articles to be dried are placed in enclosed rooms, the walls and floors must be wetted down periodically, so as to provide the moist atmosphere. Fine lacquer work requires 18 coats; it improves in colour with age. If Japanese lacquer

were used only for bric-a-brac and woodwork, we would not give its description space in this article, but it has a much wider use than that held by general opinion. It is widely used for metal coating—the Japanese use it for acid tanks, for ship's coating, for coach and decorative panels, and for domestic articles, which it enables to resist hot water, soap, and alkaline solutions. It never splits or cracks, and has great durability. Applied to the hulls of ships, Japanese lacquer forms a coat both anti-corrosive and anti-fouling. The coats applied to hulls vary in composition, the first being almost pure lacquer, and the succeeding coats containing proportions of mica or kaolin to increase the covering power. When first used as a ship's paint, anti-fouling paints were applied over the lacquers, and this method was a failure, the urustric acid in the lacquer attacking the metallic base of the anti-fouling paint, the result being that the virtues of both were destroyed. Later, it was found that the lacquer alone is an admirable anti-fouling paint, as well as an anti-corrosive protection.

The Bower-Barff Process. The Bower-Barff process of coating iron and steel is old, the two inventors from whom the process derives its name having registered their patents over twenty-five years ago. But the process did not obtain prominence or commercial success, on account of certain inherent difficulties which gave bad results. It remained for followers of the original inventors to carry the process some way nearer perfection, so that the modification of the original process now followed by those who practice *barffing*, as it is usually termed, may be said to be both a practical and a commercial success.

The root principle of the barffing process lies in this—that when iron or steel is made red-hot, and steam is brought into contact with it, the surface undergoes a chemical change and becomes black oxide, or, as it is more properly called, magnetic oxide of iron. We need not waste space in describing the plant used by Bower and by Barff respectively in achieving their objects. Our time will be better occupied in paying attention to the modern improvements upon the original methods adopted.

No other metals but iron and steel can be subjected to barffing with successful results, hence its use is somewhat restricted. But the process is less expensive than galvanising, and, if carried out as it now can be carried out, the surface given to the metal is even more resistant to corroding influences in exposed situations. The finish is a dark slate or dead black—the natural colour of black oxide, and the depth deepens upon the length of time to which the articles are subjected to the process. The bad results in early attempts were that the magnetic oxide surface given to the iron or steel was very hard and brittle, being liable to scale. This difficulty has now been almost entirely obviated. Certainly, articles barffed to-day do not give evidence of peeling in the manner and to the extent that formerly prevailed.

The present-day practice usually followed is the Gesner modification of the original. This consists in heating the work in a closed retort, and injecting steam for some time. The steam is shut off, and a small quantity of naphtha is admitted, after which steam is again injected. Finally, the work is allowed to cool naturally, and is then finished.

The Barffing Furnace. The furnace used is much like a coal-gas furnace, consisting of one or more clay retorts, which may be made to open at one or both ends. The fuel used is immaterial, as the work is isolated from the fumes, and local convenience decides the point. Steam is led from a boiler into the retort by a suitable pipe. The steam need not be under pressure, and an ordinary house boiler is quite suitable for its generation. The steam-pipe is led along the bottom of the retort, protruded from the end opposite to that by which it entered, is returned, and its end led into the retort again. The object of thus causing the steam-pipe to travel the whole length of the retort before the steam is allowed to escape is that the steam is superheated before coming into contact with the work. This is an essential feature of Gesner's method. Another essential feature is the use of a hydrocarbon, such as naphtha, with the steam. The theory of the inventor of this process, and his claim to success, rest in the fact that the steam, passing through the red-hot pipe in the bottom of the furnace, is partially reduced, that hydrogen and oxygen are set free, and that these, acting in conjunction with the steam, give a coating of magnetic oxide containing oxygen. Such a coating is, by experience, found less liable to scale than one devoid of hydrogen. Analytical tests made have shown that the magnetic oxide coating contains about 1 per cent. of hydrogen. The door of the retort is made reasonably tight to prevent the escape of steam, and clay is plastered around it with this object. An exhaust pipe is led from the top of the furnace into a water-seal, which gives a low pressure in the retort. About 1½ in. of water is usually all that is given. The arrangement of the furnace is calculated to give as nearly as possible a uniform heat in the retort.

The articles to be barffed must be free from scale and dirt. The better and smoother the finish before barffing, the better is the resultant coat of black oxide. The castings or other articles under treatment may, if greasy, be treated with caustic soda; but if free from grease, this is unnecessary. To remove scale or dirt, they may be pickled or sand-blasted. The latter treatment is the better.

Operating the Process. The retorts in which the work has been placed are heated to from 1,000° F. to 1,200° F., and the steam admitted for about 30 minutes, and then about a pint of naphtha is allowed to enter through a pipe for that purpose. Then steam is allowed to enter alone for about another 30 minutes, and is finally shut off. When the retort has cooled to about 800° F. the articles are removed, and, to prevent marks or imperfections on the surface, they are put into paraffin or other heavy oil while still hot. They are taken out afterwards, the oil is removed by immersing the articles in benzene, and a coating of flat lacquer or wax or both is given. A little polishing follows upon a rotary bristle brush. For coarse work, such as cast-iron furnace pans, for which barffing is largely used, many of the refinements enumerated above are not practised as this would raise the cost where cheapness is of more importance than elegance; but for light hardware the process usually employed is that we have described.

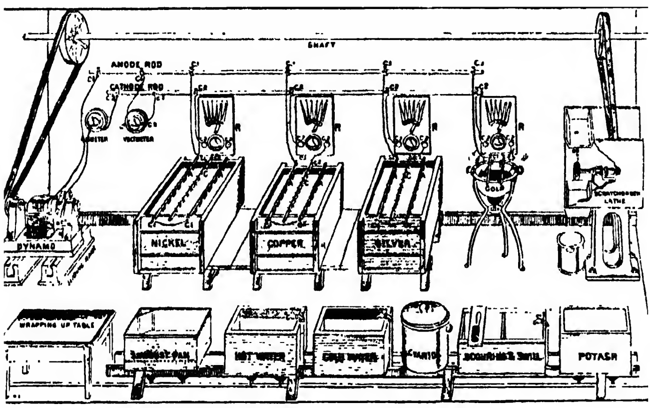
The cost of the process for large work such as furnace pans may be as low as from 4s. to 5s. a hundredweight, but for lighter and smaller articles it is much higher, and may be as much as 20s. a hundredweight. The expense in small articles is because every article placed in the retort must be deposited so that every part of its surface may be subject to the action of the steam.

The original process of barffing increased the size of the work, and as the work could not be machined afterwards without destroying the surface produced, provision had to be made in initial preparation.

The formation of hydrogen during the modified process we have described seems, however, to prevent this enlargement, and machined work—screws, nuts, valves, and other articles—may now be made to finished sizes and barffed without fear that the process will disturb the fitting.

Electroplating. The principles and the practice of electroplating are treated in the course on ELECTRICITY [page 3421], and it is assumed that the reader has made himself familiar with the instruction given there. Space may be spared here for some practical information upon the equipments required for various classes of work and for different volumes of output.

The most common form of electroplating is a deposition of a deposit of nickel upon steel or iron, and in many plating shops, particularly in the cycle trade, no other work is undertaken. We may therefore consider such a shop. A plating plant, capable of treating up to 30 sets of cycle fittings per week, would include a dynamo (6 volts, 100 amperes) driven at 1,200 revolutions, and requiring 1½-horse power; a nickel vat, 4 ft. by 2 ft. by 2 ft. deep; a copper vat 30 in. by 18 in. by 18 in. deep; and a polishing lathe. It is never wise to purchase a plant that will overtake only the amount of work available at the moment, as in the event of increase of work the plant will not be able to rise to the work. It is considered well that the capacity of the plant should be 30 to 50 per cent. higher than there is immediate occasion for. The size of the vats and the quantity of solution depends upon the quantity and size of the articles to be plated. Every square foot of surface of work being plated requires 10 amperes of current, and this forms the guide in determining the size of the dynamo necessary. The dynamo should be fixed in a convenient position as close to the vats as possible. The grinding and polishing should never be done in the same shop or room as the plating.



ARRANGEMENT OF PLATING SHOP

The Plating Plant. A complete plating plant, as arranged by Messrs. Canning, of Birmingham, is illustrated herewith. The plating vat must be lined with chemically pure lead with burnt joints. The nickel anodes should be pure cast nickel plates, having an aggregate surface at least equal to the surface of the work, and if rolled nickel plates be used at all they should not be more than one to four cast anode plates. The nickel solution is made by dissolving sulphate of nickel in water. The trade in this country usually employ Canning's special nickel salts—a double sulphate of nickel and ammonium—dissolving one pound by weight in one gallon of clean boiling water in a vessel of wood, earthenware, or enamelled iron. The solution as it becomes impoverished is brought to strength again by the addition of more nickel salts. It must be kept neutral, and if through use it becomes acid, ammonia is added in small quantities to bring it to neutrality. The anodes are suspended in the tank from brass rods as seen in the illustration, and the articles to be plated are also suspended from suitable hooks or baskets. The best practice is to have anodes at each side of the work so that with three rods the centre one carries the work and the other two the anodes, and if five rods are used the centre and the side rods carry anodes. A recent improvement in electroplating plant has been introduced by Messrs. Canning and widely adopted. By mechanical agitation of the electrolyte the current density is increased, and the time taken to form the electro deposit is reduced by as much as one half. The direct result of the introduction of mechanical agitation is to double the capacity of any plant.

Electro-brassing and Electro-coppering. The same process as for nickel plating is used in depositing any other metal, but the anodes used must be of the metal it is desired to deposit. Thus, anodes of gold, platinum, silver, brass, copper, tin, or zinc are used as required. We may take as typical electro-brassing, as after nickel plating it is the most generally practised. The electrolyte used may vary in composition, but the following is good (Canning):

Pure cyanide of potassium	1 lb.
Carbonate of copper ..	8 oz.
Carbonate of soda	3 oz.
Bisulphate of soda.. ..	1 oz.
Water	1 gal.

In making, dissolve the cyanide of potassium in three quarts of hot water, and add the carbonate of copper. In a separate vessel dissolve the carbonate of soda and the bisulphide of soda in one quart of hot water. Mix the two solutions when cold and stir well. The electrolyte may be used either hot or cold; if the latter, the temperature should be 120° to 140° F.

Before immersion the work must have been thoroughly cleaned in hot cleaning solution (hydrochloric and sulphuric acid in 10 parts of water) and swilled, then scoured with powdered pumice-stone and again swilled. The full details for depositing other metals cannot be given in this article. There are several good textbooks to guide the novice; the "Handbook on Electroplating," published by Canning & Co., of Birmingham, may be recommended.

Finishing Plate Articles. When a nickel-plated article leaves the electrolyte it has a dull-white appearance. It must be finished. It is first rinsed in hot water and then dried. Then it goes to the finisher, who, with the aid of mops made of felt, calico or swansdown, usually mounted on a polishing lathe, polishes the work, the final touches being given with a soft clean mop. The first mop is usually charged with dry Sheffield lime or with tripoli powder.

METALS *concluded; followed by* MINERALOGY

CABINET-MAKING

Veneering. Inlaying. Furniture Construction. Table Tops. Carcases. Fitting of Shelves, Backs, and Tops. Framed Work. Staining and Polishing

By W. J. HORNER

NO sharp distinction can be drawn between cabinet-making and joinery any more than between carpentry and joinery, though in each case it is easy to give specific instances of work that is within the exclusive province of one or the other Joinery occupies an intermediate position, and is overlapped at one extreme by the rough and heavy work of carpentry, and at the other by the fine and neat work of cabinet-making. Such work as plain furniture, and shop, bank, and office fittings may be done either by cabinet-makers or joiners, the choice depending chiefly on the degree of finish required. With the exception of plain deal articles the construction of furniture is regarded as cabinet work. With a few exceptions the tools employed and the methods of jointing have been described in the courses on Carpentry and Joinery.

Woods Employed. In cabinet-making, hard wood is chiefly used, and the soft varieties, in which the bulk of carpenters' and joiners' work is done are generally used only under veneer and frequently not even then. A great number of fancy woods are used, but for large articles the list is very much reduced owing to the unsuitability or cost of many of the rarer woods. Mahogany is the most commonly employed and is one of the best for furniture, owing to its small liability to shrink and warp. For many years after it came into general use it was to the cabinet-maker what oak was to the carpenter, and what deal is to the latter craftsman at the present time. There are two main varieties, the Spanish, which is valued for its rich appearance and hardness, and the Honduras, or baywood, which is softer, straighter grained, lighter in colour, and cheaper. The chief other woods used are oak, walnut, ash, and birch. The important woods have been described in the first article of the course on MATERIALS AND STRUCTURES, beginning on page 51. Soft woods, such as pine and American whitewood, are used a great deal for parts that do not show, such as backs of carcases and drawers, drawer bottoms, runners, and sides. They are used also covered with veneer, or in some cases—drawer bearers, for instance—may have a hard wood facing about ½ in. thick, glued on the front. All wood in cabinet work must be thoroughly seasoned. Artificial drying in kilns is usually resorted to. There are many varieties of these.

Furniture Designing. This is not done by the journeyman cabinet-maker, but by specialists, who make the drawings for him to work from. These drawings are usually not very elaborate compared with the drawings required in some other trades, for exact dimensions are unimportant, and many details of construction can safely be left to the judgment of the workman or his foreman. A single perspective view of an article with its leading dimensions is therefore often sufficient for a cabinet-maker to work from, and in some cases no drawing at all is made. Drawing is supplemented a great deal by written instructions. The designer must be familiar with methods of construction, or he will cause needless trouble and expense with perhaps weak and unsatisfactory results. Apart from this, he is chiefly concerned in designing goods that will best command a sale. So much variety has gone before that new designs now are new combinations of features of old designs. It might be quite possible to design something absolutely new, but the demands of utility and good appearance would almost certainly condemn it. The first essential in any article of furniture should be a design which makes it convenient for use. All ornamentation and considerations of appearance should be subsidiary.

The Value of Appearance. In cabinet work appearance has to be considered more than in other woodworking trades, and though utility should never be subordinated to it, it makes a difference between the work of the cabinet-maker and that of the joiner and carpenter. Good work is desirable throughout in an article of furniture, but only parts that are constantly visible are finished neatly, while backs and under parts are left rough. Another thing peculiar to cabinet work is that strength is in most cases of less importance than appearance. Furniture is not supposed to be subject to rougher usage than when serving its normal purpose, and the cabinet-maker constructs it on that assumption. In the jointing of light framework, for instance, stub tenons or dowels secured by glue alone are typically cabinet work. In many articles, however, the appearance of strength is desirable, and thus we have pilasters formed by gluing thickening pieces against thin sides, and the lining-up of horizontal pieces, and addition of solid-looking plinths and cornices. In some cases the purpose of an article permits of great latitude in fixing dimensions, and then proportions are adopted which look well. Thus an article of rectangular shape is not made more than twice as long, or high, as it is wide.

Changing Fashions. The design of furniture is subject to slow changes of fashion. As with dress, and other things, the style of which changes without necessarily improving, this is caused by a desire for distinction among wealthy people and desire among poorer ones to imitate them, a new fashion being adopted by the former as soon as the reigning one has become common property. Besides this, public taste varies at different periods, and the style of furniture varies correspondingly. It is possible, however, that the changes of the future will be slight compared with those of the past, because extremes in all directions have been reached and recognised as unsatisfactory. The best furniture is made primarily to serve its purpose perfectly, and secondly, to please the eye. The highly ornamental and the severely plain, alike, generally fail in both these directions.

A complaint frequently made is that furniture is less substantially made than formerly. The assertion is less true now than it was some years ago, but the time has gone past when quality and methods did not vary much from a set standard. If the best work now is not superior to any that has ever been done before, it is because better work is impossible. No one can dispute that a great deal of modern work is trashy, but as such work does not last we have no

means of knowing whether the workmen of a century or more ago were equally skilful in that direction. Probably they were not. The rank and file, no doubt, were ignorant, simple-minded men in a position to take as much time as they pleased to do anything. They had a high opinion of their manual skill, and exaggerated notions of the importance of trade secrets, in many cases not to be imparted freely to each other, and still le s to the outside public. Modern conditions are different. Work is done now much more expeditiously and consequently at comparatively far lower prices. In many cases the cost of labour is a trifle compared with the cost of material. This is not because wages are low or because manual work is done more rapidly than formerly. It is because the workman now is assisted by machines which perform all the operations that before occupied most of his time. The subdivision of labour now prevailing also conduces to rapidity of production.

Old and Modern Work Compared. Neither machine work nor subdivision of labour means inferior work, but rather the contrary. In some respects the best of the very old work was rough compared with the best modern work, and its roughness was not compensated for by its being any stronger than what is made now. We have only to notice the construction of old furniture preserved in museums to perceive that. Articles elaborately carved and inlaid are often jointed more roughly than would be permissible now. The use of wood pegs in tenoned joints, with the end grain of the pegs showing in the front faces of the work, and generally projecting about a sixteenth of an inch through shrinkage, would be intolerable in the cheapest modern articles. Old work suffered also through being done by men who were not specialists. There are few men who can do both heavy and light work with equal accuracy, and no one man can be as skilful at half a dozen classes of work as the same number of specialists assisted by machinery can be.

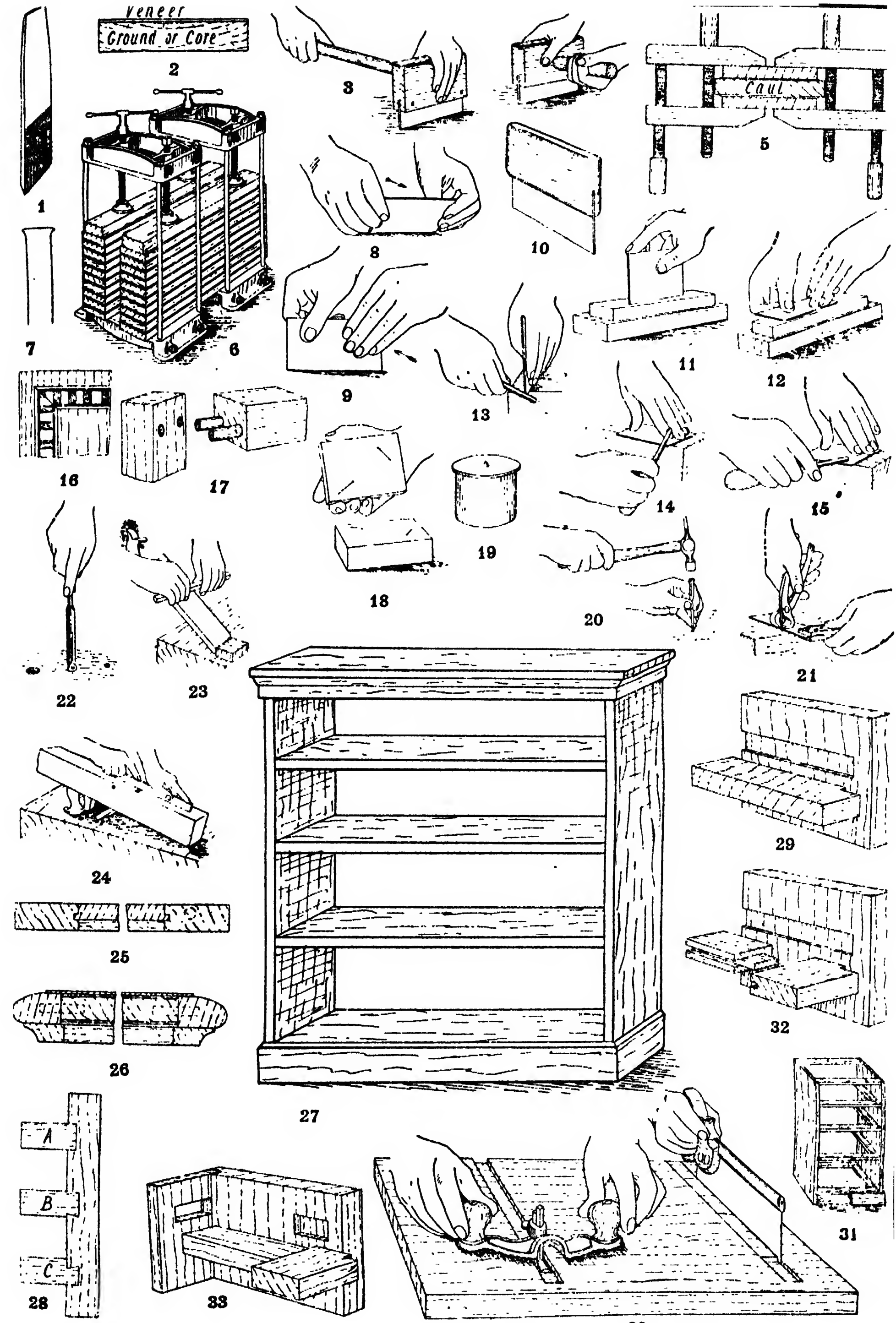
The Element of Time. If it be untrue to pretend that our best is not equal to the best that has gone before, it is still more untrue to suppose that our men are not equal to their predecessors. Only those whose admiration for the past is based on unreasoning sentiment can believe so. So far as we can judge of them, there is no reason to doubt we not only have their equals, but have far greater numbers of them. But in most work nowadays the element of time has attained an importance it never had before. Most classes of work are so often repeated that the time they should occupy is known or can be estimated almost to an hour, and it is to the workman's discredit if he exceeds this almost as much as scamped work is to his discredit. The test of a first-class workman is to do work of the best quality in the minimum time. If an unlimited amount of time is allowed, a far less skilful man can equal the product in quality. A first-class workman, however, has not always the opportunity to do the best work. Quantity instead of quality may be required of him. There is a large demand for cheap articles, the cost of which is cut down by employing inferior material and quicker methods of construction. Their unsubstantial character does not indicate that they were made by incapable workmen, but that their cost was not allowed to exceed a certain amount. Work of this kind is justifiable because it supplies a demand, but in the case of the cheapest work it may be doubted whether the demand would be very great if the average purchaser was capable of seeing its defective character.

Modern Subdivision of Trade. Cabinet-making, even more than most trades which have attained a high degree of development, is very much subdivided. It has first of all two natural divisions, for there is a decided difference between carcase work, such as wardrobes, chests of drawers, etc, which are boxed in, and open framework, such as that of chairs. Chairs are so different to ordinary cabinet-maker's work that people employed in their construction are known as chairmakers, and not as cabinet-makers. Chairs differ so much from each other, however, that the chair-making industry is itself very much subdivided. But even among articles of furniture which do bear considerable resemblance to each other, it is found more economical for firms to confine themselves chiefly to one, and portions of that are often purchased ready made. In no case is all the work on one article done by one person. All turned parts are done by a wood-turner. Carving is done by a carver or by machinery. Veneering and inlaying are done by specialists. Polishing and upholstering are done by men of those trades. Among the operations just mentioned the only ones that can be considered as branches of cabinet-making are veneering and inlaying.

Veneers. These are thin sheets of fancy wood ranging in thickness from that of a thin sheet of paper to ¼ in. They are used a great deal in cabinet work, and to a less extent in joinery, for gluing to the surface of cheaper wood to improve the appearance of an article. In some cases also curved parts are built up entirely of veneer by gluing a number of thicknesses together. *Ply wood*, which is now largely used for panels and drawer bottoms, is built up in the same way with the grain of the layers crossed. These, however, are not veneer in the ordinary sense, but plain cheap wood sawn thin. The most expensive furniture woods, and especially pieces of exceptionally handsome appearance, are seldom used for anything else but veneer, for it would be considered a waste of valuable material to use it in any other way unless for articles so small that the amount of material used in them is not worth considering.

Veneer is cut by special machinery, and comes into the cabinet-maker's hands ready for use. It is known either as *knife cut* or *saw cut*, according to the method of cutting it to thickness. By the knife-cut process it can be cut very thin, and there is, of course, no waste in sawdust. From 30 to 40 thicknesses may thus be obtained from 1 in. By sawing, about one-third that number is the most possible, but sawn veneer is thicker and for most purposes, better, though more troublesome to glue. Saw-cut veneer as used for most purposes is about $\frac{1}{16}$ in. thick. Very thin knife-cut is sometimes backed with paper. This prevents it from splitting and warping. Warped veneer may be flattened by damping and putting under pressure between warm, dry boards. Knife-cut veneer may be either sliced or rotary-cut in a kind of lathe. The log is steamed or boiled before cutting, and the cutting machinery is very heavy and rigid, so that a sheet of tissue paper thickness can be cut if desired.

Veneering. The methods of gluing veneer differ in some respects from those of making ordinary glue joints. This is owing to the thinness of the veneer and the large surface to be glued. There are two methods; one by means of *cauls*, which practically means cramping the parts till the glue is set. The other by the use of the *veneering hammer*, which means squeegeeing surplus glue out by sliding pressure on the veneer, and the latter in such cases is always so thin that it remains



1. Toothing plane-iron 2. Veneer on heart side of wood 3 and 4. Veneering hammer 5. Two pieces of wood veneered with caul between 6. Veneering presses 7. Edge view of a scraper 8 and 9. How to use a scraper 10. Scraper in a handle 11. Smoothing the edge of a scraper 12. Removing the burr 13 and 14. Sharpening 15. Preparing for re-sharpening 16. Inlaid banding 17. Example of dowelled joint 18. Dowel centres marked by pins 19. Centre pop 20. Punching a nail 21. Withdrawing a nail 22. Countersinking with a gouge 23 and 24. Using saw and plane in inverted position 25. A panelled top 26. A top with softwood core 27. Example of a carcase. 28. Methods of fitting shelf ends 29. Shelf end with stopped rebate 30. Method of cutting grooves for shelves 31. Case or pedestal with drawer runners 32. Fitting of runners 33. Another method of fitting runners

in contact without further treatment. This latter, however, is considered only a makeshift method, to be employed when cauling is inconvenient.

The wood on which veneer is to be laid must itself be carefully chosen. A hard close-grained wood does not adhere well to a soft one. Soft woods, such as pine and American whitewood, are very commonly used beneath veneer, but in the best work Honduras mahogany would be employed as a groundwork. Knots should be cut out and pieces of ordinary wood fitted and glued in their place. Small holes should be filled with plaster of Paris. The surface, after being planed, is roughed with a *toothing* plane and sized with thin glue. A toothing plane iron is shown in **1**. It fits nearly vertically into a plane body resembling an ordinary smoothing plane. The serrated edge of the iron scratches the wood and leaves a surface on which the veneer is not liable to slip and the glue obtains a good hold. Two toothing irons of different degrees of coarseness should be kept, as a finer iron is needed for hard wood than for soft. Another method sometimes adopted is to go over the surface with coarse glasspaper on a flat rubber. The veneer is toothed also when sufficiently thick. Rounding surfaces are rasped and roughened with coarse glasspaper. Where a piece of board is cut tangentially to the annular rings of the tree and only one side of it has to be veneered, the veneer should be laid on the heart side, as in **2**.

Veneering with the Hammer. The veneering hammer is used as in **3** and **4**, to press out surplus glue. The hammer has a handle about 1 ft. long and a head about 6 in. square by 1¼ in. thick, with a piece of thin iron inserted in a saw-cut in its lower edge and secured by screws. The edge of the iron, which is used to press the veneer, is rounded slightly and made smooth so as not to injure the surface. In addition to this, soap is often used to enable the hammer to work freely without sticking. Hot water is also sparingly applied to the upper surface of the veneer, chiefly to counteract the tendency to curl when it is wetted by the glue on the other side. The glue is spread as rapidly as possible on both the ground and the veneer; the veneer is laid on the ground and pressed down, and then the hammer with heavy pressure on its head is worked about the surface to force as much glue as possible from the centre out to the edges. The easiest way to move the hammer when pressing on it is to work the handle from side to side while moving it forwards or back, thus giving the head a zigzag movement over the veneer. The veneer, as a rule, will remain in close contact after the hammer has been passed over it, but sometimes blisters may be seen or detected by tapping. In such cases the glue beneath may be remelted if necessary by the application of heat, which soon penetrates the veneer. A hot flat iron is generally kept ready for this purpose, and a damp cloth first laid on the place where it is to be applied. The blister will then generally remain down or if it is obstinate a weight may be put on it for several minutes. A bowl of hot water is placed on the bench when the veneer is to be laid, and the hammer, when not in use, is put in the water to keep its edge free from hardened glue. A sponge and one or two pieces of cloth are kept in the water, too. The gluing must be done in a warm atmosphere free from draughts, and the glue applied as hot as possible, so that the veneer may be properly laid while the glue is still quite liquid. Veneer can be removed if necessary by the application of heat and oil or water to loosen the hold of the glue, but it is never worth while to do this, as the veneer would be practically spoilt in the process. Bad places in veneer are better rectified by cutting them out and fitting other pieces in. A piece with grain as nearly like it as possible should be laid on top, and an irregular cut made through both, following the grain as much as possible to make the joint unnoticeable. An inlaid piece cut geometrically square or circular is much more conspicuous. Air can be released from a blister if necessary by making a small puncture. If more glue is required beneath a slit must be cut with the grain.

Veneering with Cauls. A caul is a piece of wood, zinc, or other material, of the size required to cover the surface to be veneered. It serves two purposes. One is to contain heat to make the glue run freely when it is cramped on. The other is that, veneer being too thin to have any rigidity in itself, uniform pressure must be applied all over its surface, and cramps alone would not do this. When a surface is large, its area may be covered equally well by a number of cauls placed side by side. For curved surfaces, cauls shaped to fit the curve are required, but in most work surfaces are flat, and the cauls are flat pieces of wood of about 1 in. to 1½ in. thick, sometimes kept specially for the purpose, sometimes selected from the stock of wood used for ordinary work. For permanent use they are better covered with sheet metal, preferably zinc. This not only preserves their edges from wear and reduces the risk of splitting and warping, but glue from the veneer does not obtain a hold on it, and consequently it cannot get stuck to the work, as is sometimes the case with wood cauls, for glue makes its way through thin veneer. Another reason why metal is preferred is that cauls have to be heated before they are applied, and, if care is not taken, the wood ones are liable to get spoilt through burning. Neither do they retain heat as well as metal cauls. Small cauls may be merely plates of zinc ¼ in. to ⅜ in. thick. Large ones are backed with wood. Cauls of irregular shape, and consequently troublesome to make, are, if constantly required, usually made of cast iron. For temporary use a bag of sand may serve as a caul on a surface of any contour, and may be heated and cramped on the veneer. Cauls are cramped to the surface by any convenient method.

For small work, hand screws are generally used [**5**], and, as in using the hammer, pressure should be applied first to the central parts to force the glue outwards to the edges. In **5**, two pieces are veneered with one caul between them. Wood cauls should always be soaped to prevent their sticking and pulling pieces of veneer away. Zinc cauls are soaped also when working with very thin veneer. In using cauls, only the dry heat of the caul is employed, and therefore the work is dry and hard in much less time than is required for hammer-laid veneer, in which the surface is wetted with hot water. The cauls and cramps are left on for several hours, until the glue is set. For work on a large scale, metal presses [**6**] with powerful screws are used, and a number of boards with veneer on are put in a pile and very heavy pressure applied, a number of presses, about 6 in. apart, being used to press long pieces. The boards are passed through machines which apply the glue very rapidly. For work on a small scale various kinds of wood presses are made by the workman, the principle being similar to the iron press shown, but wedges, instead of screw power, are the usual method of applying pressure. Joints and cracks in veneer are kept together and the glue prevented from coming

through and sticking to the caul, by pasting paper or canvas over. In some cases it is a practice to cover the entire face of veneer with paper. This is cleaned off after the cauls are removed.

Veneer is cut to dimensions by laying it on a flat surface, using a straightedge on it as a guide, and cutting with a sharp chisel or knife if the veneer is thin, or with a saw if it is thick. Joints on a surface are made by lapping the edge of one piece over the adjoining one, and then by cutting through both. Veneer should always be put on larger than required, and the edges trimmed off afterwards, otherwise there would be trouble in setting it correctly into position while gluing. The best veneer is generally put on panels, because the figure or grain of the wood is more noticeable there than on narrower parts. Often they are *cross veneered*—that is, a plain piece of veneer is first put on across the grain, and this is afterwards covered by the final veneer with its grain running the same way as the *ground* or *core*, as the interior wood is called.

Veneers on panels and other large surfaces are sometimes cut and jointed geometrically, pieces cut out from the same log being turned with grain reversed towards each other, so that similar curls and twists incline to the joint from opposite positions. Parts may be stuck down and pieces fitted in to make bad places good, as described for hammer-laid veneer.

The Scraper and its Use. The scraper is a small piece of sheet steel about $\frac{1}{32}$ in. thick. Its usual form is rectangular, measuring about 6 in. by 3 in. Often a greater length and less width is found convenient, but in any case its original dimensions soon become reduced by wear. Other forms are curved to suit hollow or round surfaces. Its edges are made very keen by first squaring and then slightly burring or turning them over, as shown to an exaggerated extent in 7.

The scraper is a tool frequently used by joiners, but to the cabinet-maker it is indispensable, and is used after the plane on almost all surfaces. The hard wood used by the cabinet-maker is often too cross-grained to be planed at all without tearing up the surface and leaving it worse than when sawn. But even when it can be planed smooth, the marks of the plane show as a series of undulations across the surface, and although these might be removed by glasspaper on a rubber, it would be difficult to produce as smooth a surface as can be done with a scraper in less time. The scraper, therefore, generally follows the use of the smoothing plane and is itself followed by a rubbing down with very fine glasspaper.

The scraper is held and worked at an angle as in 8 and 9, so that the sharp edge can be made to scrape or cut a very fine shaving when moderate pressure is exerted. Sometimes the steel is fitted into a wood block which serves as a handle [10.]

The sharpening is effected as follows: The edge is first ground or filed square and straight with a very slight amount of rounding up at each end, so that the corners will not leave ridges on the surface of the wood. Next, while still keeping the edge square, it must be made perfectly smooth. The best way to do this is by rubbing it on an oilstone [11]. The edge must be rubbed with the scraper vertical on the stone, and each face must also be rubbed [12] to remove the ragged burr which gets turned over in grinding and smoothing the edge. The edges should now be square and smooth with sharp angles. It is necessary now to burr or turn these angles uniformly so that they shall be very much keener than they are at 90°. This may be done with the scraper in either of the positions shown in 13 and 14. Another way is to hold the scraper in a vice. A short rod of steel in a handle is the proper tool to turn the edge with, but very often the back of a small gouge is used for the purpose. In 13 the scraper is shown held in a vertical position with its lower edge resting on the edge of a bench. In 14 the scraper is laid flat on the bench with the edge to be sharpened projecting slightly over. In both cases the sharpener is held at a similar angle in relation to the edge of the scraper. With the sharpener slightly tilted as shown, and pressing as heavily as possible, it is drawn sharply along the edge, turning over a slight burr as it goes. This burr is imperceptible to the eye, but is sufficient to scrape a wood surface far more effectively than would have been possible before this operation. If sufficient pressure is applied, one stroke of the sharpener is enough, but if not, more may be made. The edge soon becomes dull with use and requires re-sharpening, and after this has been repeated a few times, the edge becomes so worn that it is necessary to re-grind. In re-sharpening, the turned edge is generally rubbed flush, as in 15, before the sharpener is used to turn the edge afresh. All the edges of a scraper may be sharpened in this way so that each can be used in turn till too dull to cut.

Inlay. The inlaying of ornamental design into a surface is frequently practised to decorate cabinet work. To a person unacquainted wth the practice it might be supposed that the effect was obtained by staining or painting the design on the surface. The difference in colour is obtained by the use of different woods, and in a few cases, where such colours as blue or green are employed, by staining the inlaid wood before insertion. Wood is the chief but not the only material used as inlay. Others often employed are ivory, pearl, tortoiseshell, and metal. It is then called *buhl* work. The inlaid material is always very thin and is glued in place. This is more frequently done in veneer than in solid wood, and the thickness of the veneer usually represents the depth to which the pattern is inlaid. The forms of inlay range from simple straight lines of white or black wood about $\frac{1}{16}$ in. wide, round the edges of surfaces, to representations of flowers and scenery. Figure 16 is an example of stringing and banding round the margin of a surface. The term inlay includes all inlaid work, but different names are given to different classes of inlay. Work of complicated outline, such as representations of natural scenes and highly ornamental patterns, is known as *marquetry*. Geometric patterns are called *parquetry*, and this term is now applied chiefly to floors laid with hardwood blocks arranged in any geometric pattern. *Intarsia* is a very simple kind of marquetry in which pictorial effect is obtained by a few pieces of inlay, the grain and outline of which represents a land or sea-scape without detail. Buhl work, as already noted, is inlay of other material than wood.

Methods of Inlaying. Inlaying of the more complex character is not done by cabinet-makers, but panels or other parts are purchased already inlaid, or inlaid veneer is purchased and either laid on large enough to cover the surface it is required for, or the inlay is contained in a small piece of veneer cut to oval, circular, or other shape, and let into the body of the other veneer. Patterns of plain outline are also sold separately. Built up patterns and inlaid veneers when purchased in this way have their parts united by being stuck on a backing of paper. This is the usual method of forming patterns even when done by the person

who afterwards intends to inlay them in another surface. The paper is intended to be on the outer side when the pattern is inlaid, so that it can be cleaned off when the glue is set. If turned the other way the paper would prevent the glue from holding the inlay properly, for paper can easily be split if glued between two pieces of wood.

Fitting Inlay into Veneer. There are two methods of fitting the parts of patterns together and fitting inlay into veneer. One is to cramp or stick temporarily the pieces face to face, and cut through both with a fine saw or sharp knife to the outline required, thus obtaining an interior part which will fit into a corresponding exterior one. The other is to cut a pattern out separately, and lay it on the surface in which it has to be sunk, and mark its outline with a sharp pointed knife or scriber, and cut out to these lines. For inlaying into solid wood, this latter is, of course, the only method. Incision is made to the required depth by chisels, gouges, or a knife with a sharp point, and the recess for the inlay routed to the required depth, with a small *router* if in solid wood, or with a chisel when only veneer has to be removed. A router is a plane which can be set to cut a channel or recess to uniform depth. It will be illustrated farther on. But most of the inlaying the cabinet-maker is required to do is the insertion of plain parallel strings, the channels for which can be cut very rapidly with a double-toothed cutting gauge, similar to a mortise gauge, except that the cutters are deep and thin, to penetrate well into the surface. This gauge is set to the width of the inlay, and makes two parallel cuts in the surface at the required distance apart. The material between these can be removed at a stroke with a router. The inlay is glued in, and pressure put on it till the glue is set. The inlay may be parallel strips cut from veneer, or more frequently it is bought ready cut into strips known as *strings* or *stringing*. Mosaic bandings are also often employed. These are made up in innumerable patterns of different woods arranged in different ways. They are made by gluing up the patterns in lengths and then slicing off in strips about $\frac{1}{16}$ in. thick or less. The grain must run plankwise with the surface when the inlay is glued in place. Inlay designs are nearly always made in quantity either by gluing up a thick pattern and slicing off, or by sawing out a number of thicknesses together. In either case it is not regarded as cabinet-makers' work.

Other Methods of Ornamentation. Next to mouldings, which have been treated of in Joinery, carving is the most important of all decorative methods. Carved portions of work come into the cabinet-maker's hands already finished by the carver, and he is concerned only with fixing the parts in place or fitting them together. The same is true of turned work, which is done by wood-turners. This is generally not intended chiefly as ornament, but it is so easy to make turned work ornamental that it is done even in the simplest and cheapest work, almost the only exception perhaps being the use of plain parallel rods in some chairs and other articles. These, however, are not turned in the ordinary sense, but made cylindrical by being passed through a machine with revolving cutters. Another form of ornament on furniture is known as *ormolu*. This consists of metal ornaments with gold plated or gilded surface, attached to the wood by brass pins or fine screws. *Fretwork* occupies a position of some importance in light fancy articles of furniture. In this very fine saws are used to cut ornamental patterns in thin wood. The lines to cut to are transferred from patterns on paper. Fretwork for the cabinet-maker is cut by machine saws and comes into his hands ready to be attached to the work. *Pyrography*, or *poker* work is a rough means of ornamenting a surface by tracing a pattern on it with a red hot platinum point, which burns the required outline, making a slight channel in the surface of the wood, and showing as brown or black lines according to the degree to which it is burnt.

Furniture Construction. The method of constructing a given article may vary with circumstances. If the work has to be done as cheaply as possible without much regard for quality, the parts are prepared and put together in the simplest style, glue and nails being the chief means of union. If the best work is required the best forms of joints are adopted everywhere instead of the parts being allowed to depend solely on the medium which holds them together. The quality and amount of material used may also vary. Soft wood is cheaper than hard, does not look so well, and is less durable. Pieces of wood, alike in kind, vary in quality and strength. Thin material may be used for economy when thicker would be more suitable, or the strength of an article may be diminished by economising material in hidden parts. There are, of course, some exceptions where cheapest and best work must be done alike, because there is no other practicable way. The arrangement of the parts of an article of furniture has to be made with a view to exterior appearance, economy of material and labour, and sufficient strength to serve the intended purpose.

Dowels are employed more in cabinet work than in joinery. They are used very often instead of tenoned joints. Figure **17** is an example. In many cases it is troublesome to get the centres of the holes for them marked correctly by measurement or by gauging from an edge, and then other methods may be adopted. One very convenient way is to locate them by means of pin marks, as in **18**. Ordinary pins are placed in the joint, and pressure applied so that the pin heads leave imprints on both parts, which serve as centres on which to bore the dowel holes. Another method is to have a number of centre pops [**19**]. These might be made of wood with a steel point inserted, but are better turned in solid metal. The body is the same diameter as the dowel, and is intended to be inserted in the dowel hole, which has first been bored in one of the pieces to be dowelled. The thin flange shown at the top prevents it from going farther in. The other piece of wood is then adjusted in position, and a tap with a mallet, or a little pressure, causes the point in the centre to leave an impression corresponding exactly with the centre of the hole required in the other piece. Another method is to cut a piece of paper to the shape of the jointed surface and prick holes through at the places where dowels are required. The paper can then be laid in position on each surface, and the centres marked through the holes in the paper. Another way seldom practicable in cabinet work is to cramp the pieces of wood together and bore entirely through one piece into the other.

Insertion of Screws and Nails. Screw and nail heads are seldom allowed to show on exterior surfaces. Where possible they are put in from behind as described in joinery. Screws with rounded heads are preferred when the heads cannot be concealed. In some cases screws with flat heads are provided with metal cups which give a neater appearance. Nails are punched below the surface with a hammer and punch [**20**], and the holes filled flush with wax stopping coloured to

suit the wood or stain. Figure 21 shows a method of withdrawing a nail without injuring the surface of the wood. The blade of a square or other sheet metal is laid on the surface to receive the leverage of the pincers, and so prevent the wood from being bruised. Figure 22 shows how screw holes may be countersunk by scooping out with a gouge. This is not quite so neat a method as with a countersink bit, but is more expeditious, and is frequently adopted. Needle points are used for attaching light mouldings and other parts. They are similar to ordinary needles, but without eyes. They are driven in the required distance, and then snapped off flush with the surface, and, of course, are then almost invisible.

End grain appearing flush with a surface plank way of the grain is objectionable, and therefore tenons are seldom carried through unless at the back of an article where they will not be noticeable. Even under veneer through tenons are objectionable, because a slight amount of shrinkage causes them to bulge the veneer. In other cases end grain is generally allowed, if possible, to project beyond to avoid a flush joint. Except when they are glued, flush joints are always objectionable, even when the grain of each part corresponds, and consequently they are usually beaded, or moulding is attached to conceal them. The shooting board is used a great deal by cabinet-makers. Small pieces of wood are often sawn, and planed with the tools in an inverted position as in 23 and 24, the saw or plane remaining stationary and the wood being worked backwards and forwards.

Construction of Table Tops. The tops of tables, counters, sideboards, bureaus, etc., are frequently thickened or lined up at the edges, as described in Joinery; but there are several methods of building up the main surface. The simplest way is not to build up at all, but take solid board of the required length and width, and keep it flat by its attachment to the framework of the article, while at the same time allowing it freedom to shrink or swell without splitting. If very wide, this is usually done by buttoning. Comparatively narrow widths may be screwed or nailed with safety, but glue should never be used except in cases where the grain of the parts it is attached to is arranged in the same direction so that all these parts, if well seasoned, when put together can be relied on to shrink or swell similarly. Another method of keeping a top flat is to dowel or tongue flush cleats to the ends, generally with mitred corners. This is satisfactory if the wood is well seasoned, and the width not very great. A better way is to frame and panel the top with a flush panel as in 25. Here also the corners are better mitred, and the joints strengthened either by tenons or dowels. Another method is to half-lap the joint and mitre the upper face only.

The tops of writing-tables panelled as in 25 generally have the panel slightly below the surface of the frame, so that leather or cloth can be glued on the panel to make a flush surface. When solid tops are covered with leather, the border round the leather is veneer glued on. Veneered tops should have their edges corresponding in appearance with the veneer, so that it looks like solid wood, and as edges are generally moulded, and therefore difficult to veneer, the top is built up as in 26. A core of pine or cheap mahogany has an edging of more costly wood, corresponding with the veneer, glued round it, end grain pieces frequently being put on the ends. Both the upper and under faces of the core are generally veneered, so that the core is entirely enclosed. In such cases it is very often cross veneered, as in 26. Another method is to frame as in 25, making the frame of, say, mahogany or walnut, with a pine panel, and to cover this with veneer to match the frame, the veneer generally standing its own thickness above the surface of the frame, as in 26. Another way is to put a hardwood edging with mitred corners round a pine frame and conceal the latter by covering with veneer or leather.

Carcases. Carcases may be either panelled or plain boarded. Sometimes a skeleton framework of posts and rails is built to attach the panels or boards to, and sometimes there is no such frame, but the parts are fitted together at the corners in box fashion, either dovetailed, tongued, and grooved, or, in some cases merely nailed or screwed or secured by glue blocks. The method depends to a large extent on the character of the article. In cabinet work, parts are sometimes panelled mainly for appearance. Carcases intended to stand on the floor, without legs, usually have a few inches of plinth below the baseboard of the carcase. In heavy articles of furniture this plinth is sometimes separate, the carcase merely resting on it; but in most cases the sides of the carcase either extend below the baseboard, and the plinth is screwed against them, or the plinth is partly against and partly beneath, and secured by glue blocks or screws or nails.

A simple example of a carcase is shown in the bookcase [27], the frame of which, with plinth and cornice removed, would consist of two plain uprights with shelves fitted between. The uprights should, to make the most substantial job, continue to the floor, and the plinths be nailed or screwed against them from the inside, the plinths being simply an increase in the thickness of material at the sides. The plinth along the front would have the edges of uprights and bottom shelf to bear against, and would be secured by glue blocks in the interior angles. A plinth at the back would be treated similarly, but generally plinths and cornices are carried only round front and sides, leaving the back a plain flush surface. The cornice is built up by first covering the top ends of the uprights with a plain board, overlapping an inch or so at ends and front, and then fitting moulding beneath this attached in the same way as the plinths, by nailing the end pieces and blocking the front. The objection to gluing the ends is that the grain crosses. So far the constructive details have been illustrated in Joinery, but an important matter to be considered now is the attachment of shelves to uprights.

Methods of Fitting Shelves. There are a number of ways of fitting shelves, and, as a rule, in cabinet work they must be fitted securely without exterior sign of how it is done—that is, without nails in the ends, on cleats beneath, or rebates showing at the front. Shelves for books are often made adjustable, but at present we are considering fixed shelves of all kinds, including bearers and runners for drawers. In an article with plain shelves fitted to plain sides, as in 27, the shelf ends would be rebated into the sides by one of the methods shown in 28, A, B, C. The grooves in the sides, however, are stopped about ½ in. short of the front, as in 29, and the shelf ends notched to correspond. The shelves are inserted from the back. A plain rebate or housing, as at A in 28, affords satisfactory support for the shelf, and is more easily made than the dovetailed grooves at B and C; but the advantages of the latter are that they tie the sides and keep them tightly up to the shelf ends. Ordinarily, however, the plain housing, as at A, is used, and the sides are secured at top and bottom; 30 shows how these housings are cut. At the right-hand end of 30, a tenon saw is being

used to cut the depth, an inch or so at the front having previously been cleared out with a chisel to allow the saw to work. At the left of **30** a router is being used to cut the groove to a uniform depth. Generally, a chisel would be used first to clear most of the material out. A rebate plane might be employed in a long groove, instead of a router, but the fore part, which could not be touched by the plane iron, would have to be finished with a chisel.

The top of the bookcase in **27** would in most cases be nailed on, and the bottom shelf might be nailed as the plinth would afterwards cover the nail heads, but this could be avoided by the use of glue blocks beneath, and generally the ends of this shelf would fit in veed grooves and be glued.

Methods of Fitting Drawer Runners. Figure **31** represents a case or pedestal with runners and bearers to receive drawers. This is an example of sides tied at top and bottom, and requiring only plain grooves for the runners. At the bottom a complete frame stub-tenoned together is screwed or nailed into rebates, which may run right through to the front, as the front edge, and also the screw heads at the sides, are afterwards concealed by a plinth. At the top, *stretchers* are dovetailed in. The intermediate runners are then not required to play any part in tying the sides, but are slipped into plain rebates. Details are shown in **32** of a grooved side, and a runner with its tenon to fit into the bearer in front. The inner edges of runner and bearer are shown grooved, as would be the case if a panel or dustboard was to be inserted between drawers. Figure **33** shows another method in which the side of the article is not grooved for runners, but recesses are cut instead to receive the ends of the bearers at the front and the back ends of the runners at the back. In a few cases bearers are tenoned completely through sides, but, as a rule, a shallow recess only is cut. A rail or bearer connecting the back ends of a pair of runners is not necessary unless to serve as a tie to the sides, or stiffen a back. Runners are often made of oak or other hard wood, which will not get worn very readily by the drawers sliding on it.

Attachment of Backs and Tops. Backs are tongued into a groove as in **34**, or fit into a rebate, as in **35**, or in rough work are simply nailed on the surface. A back may be simply a plain, thin piece of wood, or it may be framed and panelled, or a middle course is to make it as in **36**. In **36**, A, it fits in grooves at the sides, but is not enclosed by top and bottom rails as panels would be. The muntin in the middle is screwed or nailed to top and bottom of the carcase, but the boards in the grooves may be left free to contract or expand. Figure **36**, B, is a modification of this, and is very commonly adopted. Instead of the edges of the thin boards fitting into grooves as at A, they are kept in position by one or more rebated bars, as shown at B. The thin pieces, as well as the bars, are generally nailed to the carcase.

Tops may be simply nailed on, or dovetailed in, or screwed from beneath, or fitted on to a dovetailed tongue, which may be nailed on the ends, as in **37**. In all these cases, when the grain of top and sides coincide, glue blocks may be used also, if there is no objection to their presence. In most cases tops lap over, as in **37**, but when the ends have to be flush, the best way is to dovetail them in with lap dovetails, which do not show on the sides. When tops are screwed on, the screws are usually put from beneath through stretchers, which themselves are lap dovetailed in, as in **31**.

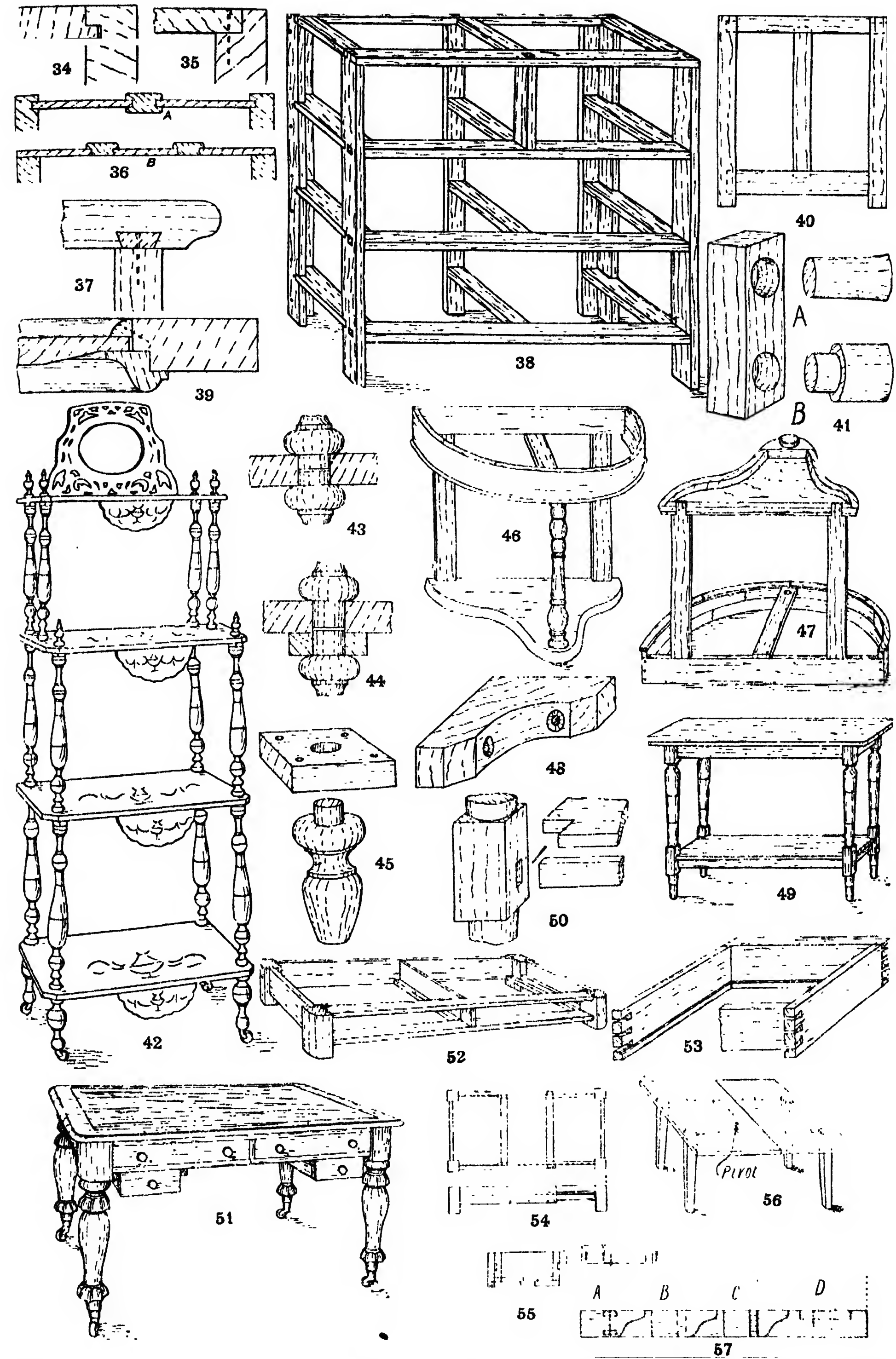
In **38** we have an example of carcase work first framed and afterwards covered as required, the boarding being attached by screws put through from the inside. It represents the skeleton carcase for a chest of drawers. All the material in the framework is, say, 1 in. thick. The boarding at the ends would be, perhaps, $\frac{3}{4}$ in.; the back $\frac{1}{2}$ in., or less, and the top 1 in. As the sides of the frame are to be covered, there is no objection to carrying the tenons through the uprights, and screwing the side and back uprights together as shown. The runners are tenoned at front and back, and notched into the side uprights. The ends of the longitudinal rails at the top are dovetailed to the tops of the uprights. The uprights at the front are, say, 4 in. wide, and all the other parts 3 in. This framework is, of course, equally suitable for attaching panelled sides and back to.

As an alternative to grooving, panels in cabinet work are sometimes inserted as in **39**, a rebate being planed or a bolection moulding glued on the front, and a fillet bradded round the back to keep the panel in.

Figure **40** is a face view of a frame for a panelled side or end showing how the bottom rail is kept above the floor. The lower part is afterwards covered by the plinth, which laps about an inch above the lower edge of the rail. The joints are either all stub-tenons, or, as there is no objection to it, the back tenons are sometimes continued through, as shown.

Framed Work. This consists of rails and posts, or legs, not boxed in, chairs being the commonest example. The parts are united by dowels or tenons, or small members have their ends housed into larger ones, or, in the case of cylindrical parts, the end of a member may be reduced in diameter. Examples of these are shown at A and B in **41**. These are usually held by glue alone, but occasionally fox wedges are inserted. But if the parts fit tightly and are well glued there is little risk of their ever coming apart. An article like **42** is built up by gluing the ends of the columns into holes in the shelves, as in **43**. If the shelves are very thin pieces may be glued to the under-surface as in **44**, to increase the depth of the stud holes, the pieces glued on appearing as part of the column. If it is desired to stiffen the shelves to prevent warping, battens may be screwed across in place of separate blocks, and the stud holes may be bored through these. The stumps of drawers are fitted into blocks, as in **44**. In some cases they are screwed in. Wood drawer knobs are generally screwed into the drawer fronts.

Figure **46** is an example of framed work in which some amount of building up is involved to obtain the required curves. It is the frame of a semicircular washstand intended to be covered with a marble top. The details of its construction are shown in **47**, in which it is turned upside down. The semicircular top on which the marble rests is formed by gluing two layers of segments which are afterwards worked to the sweep on the outside and veneered, the inside being left as it leaves the bandsaw. A bead is formed on the lower edge by nailing on a thin layer of segments with outer edge rounded and projecting. The ends of the sweep are connected by a straight rail notched in flush, and forming the back of the table part. A transverse bar extends from the middle of this to the sweep, being notched flush into the under edge of the latter and covered by the bead segments, and nailed on to the edge of the back rail, the depth of the rail being less than that of the sweep. The main purpose of this transverse bar is to provide an attachment for the top of the pillar, which comes within the curved front. The base is a piece of $\frac{1}{2}$-in. wood lined up to about 2 in., and



34—36. Methods of inserting backs 37. Top secured by dovetailed tongue 38. Carcase of a chest of drawers 39. Method of inserting panels 40. Frame for a panelled end 41. Methods of fitting cylindrical ends 42 44. An article of simple construction with details 45. Fitting of drawer stump 46 and 47. Example of framed work 48. Rough wood bracket 49 and 50. Small table with detail 51. Writing table 52. Frame of table 53. Method of constructing drawers 54. Frame of extension table 55. End view of rails 56. Table with folding and pivoted top 57. Methods of hinging brackets for flap tables

veneered. It does not rest directly on the floor, but on projections extending about an inch below the thickening or lining pieces. The two back uprights are carried through, as shown, to form feet at the back, and one other is formed at the front by a pad, which is nailed on. The pillar is slipped in after the parts are together, and nailed from above and below.

Brackets, either of metal or wood, are often used to strengthen joints. A wood bracket is shown in **48**. These are roughly sawn, but the angle of the back must be accurately finished. They are used only in hidden parts, a common instance being the interior angles of chair seats. Where brackets are required in exposed places they must be neatly finished, generally to a more or less fanciful shape, and if of wood, the screws are inserted through the work into the bracket instead of through the bracket, as in **48**.

Chairs. The seats of these, when not of solid wood or turned rings, are usually dowelled or tenoned, and glued, and sometimes strengthened by brackets of wood or metal screwed into the interior angles. The back and back legs are in most cases continuous, and the seat notched into them and screwed or nailed. The front legs are glued into bored holes. Rails connecting the legs are glued in similarly. Cross-pieces in the back are tenoned, or dowelled, and glued. Very often some of the parts are of bent wood. Special appliances are employed for making these. It is done by steaming the wood and clamping it in an iron mould, the mould itself often being formed with a chamber and pipe for steam heating its surfaces.

Tables. The methods of framing the legs and rails and buttoning on the tops of plain tables has been described in Joinery. Small tables, such as **49**, do not require such elaborate methods. The top would not be buttoned but screwed on through the rails, or if very narrow, glue blocks might be used. The rails might be housed or tenoned into the legs, but in most cases would be dowelled. The bottom rails, to which the tray or shelf is attached, might be housed into the legs, as in **50**, and the tray notched to fit the legs. The rails then would be glued in and nailed through the inner faces of the legs, where the nails would not show, though in many similar cases there is no objection to putting fine nails through from the outside if required. In some cases the tray might be attached to the under edges of the rails instead of on top, and then would be nailed to them. Figure **51** is a heavy writing-table, which does not differ greatly in constructive details from plain tables described in Joinery. Its frame is arranged to receive two drawers in the side instead of one in the end. Its top is built as in **26**, but covered with leather bordered by veneer. Its turned legs, with castors, are a detail which does not affect the construction of the table. A general view of the frame with top removed is shown in **52**. The lower bearer is tenoned into the legs while the upper one and the end and back rails are dovetailed into them. Drawers are constructed as in **53**. In cheap work the backs are nailed instead of dovetailed.

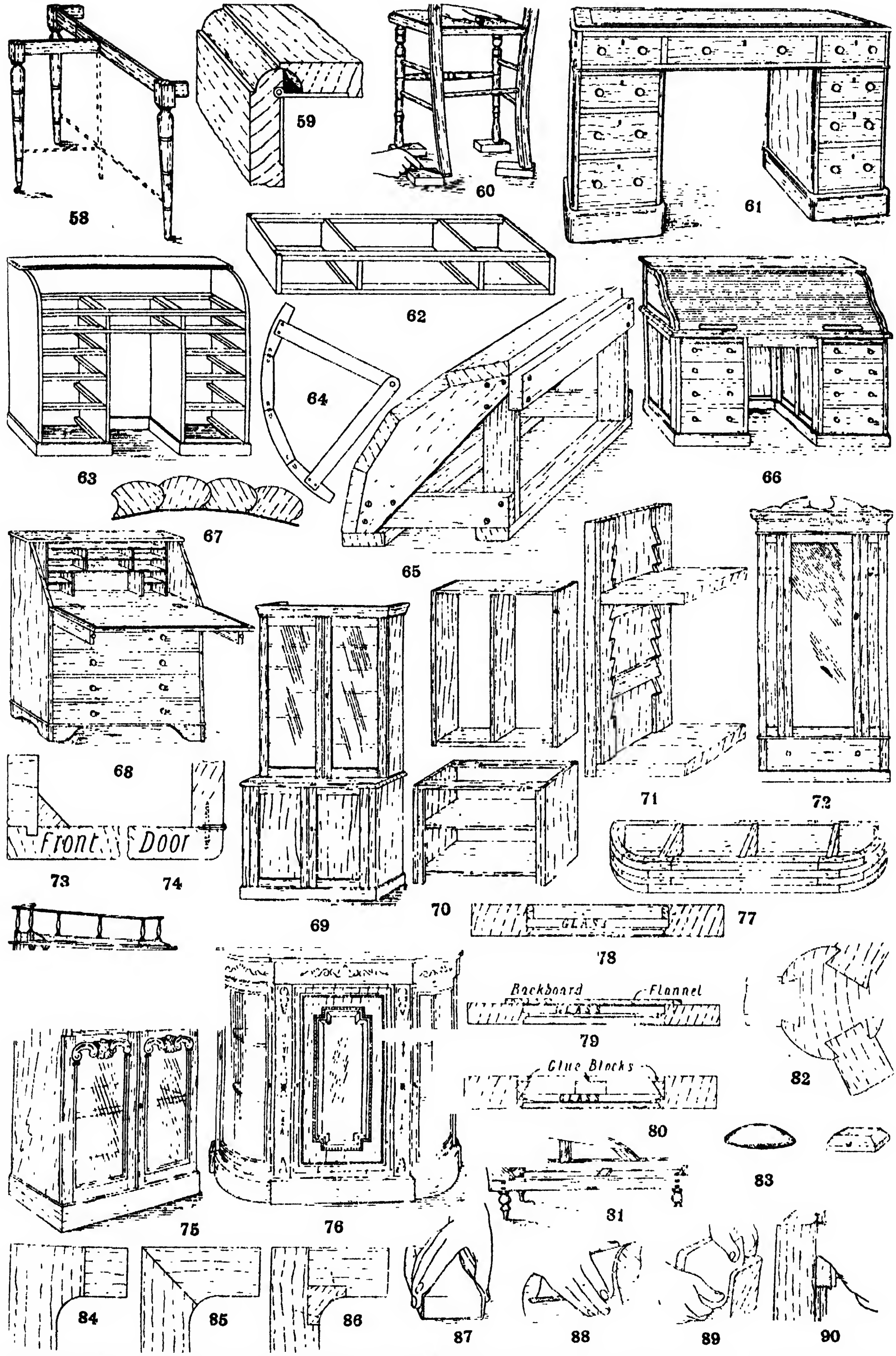
Extension Tables. The commonest form of extending table is shown in **54**. In this there are double rails secured to the legs at opposite ends, and, when closed, the free ends of each pair of rails fit loosely into housings in the legs. They are also tied laterally by stretchers. The rails are kept in alignment by tongues and grooves, usually dovetailed, as in **55**. Large tables of this class have three sets of rails, the middle ones being supported by the others or by extra legs. The frame is usually extended and closed by a screw worked by a key, and a separate leaf fills the space left when the ordinary top is opened. Another form of table with a folding top is shown in **56**. In this the top is pivoted, so that when unfolded it can be swung round at right angles to its position when closed, the long way of the frame then affording sufficient support for both flaps. When square legs of tables or other articles are tapered, as in this example, all the taper is cut from the inner faces.

Flap Tables. Ordinary flap tables have their flaps supported by brackets, swinging legs, or slides which draw out from the frame. Figure **57** shows methods of attaching brackets to the rail of a frame. The simplest is to hinge them, as at A, but for appearance the joints at B and C are preferred, C being considered the neatest; B is known as a finger joint, and C as a knuckle joint. Another way is to pivot a piece in the top of the rail, as at D, which can be swung out to support the flap. The point in favour of this is that it lies flush with the rail when closed. Swinging legs are hinged, as in **58**, sometimes with a tie near the bottom as dotted. The rule joint [**59**] is the usual method of hinging flaps.

Articles with more than three legs sometimes require levelling to prevent them from rocking, due generally to inaccuracy in the superstructure. The exact amount to cut off may be marked as in **60**, by standing the article with three of its legs on blocks of equal thickness on a true surface, and setting a fourth block against the fourth leg, which should be the one which requires cutting. The top surface of this block represents the correct length to cut the leg to. Another way is to mark from the floor with dividers instead of getting the depth from a fourth block.

Writing-tables and Desks. These are generally of the pedestal type, with a kneehole between. A table in which the top and pedestals are in separate parts is shown in **61**. The construction of a pedestal has already been illustrated in **31**; **62** shows how the top is framed. The grain of the ends runs horizontally, but in this example the table is veneered and the grain of the veneer on the upper part is made to correspond with that of the pedestals.

More frequently pedestal tables are made in one framework. Figure **63** is the carcase of a cylinder fall-desk. The sides are shown plain, but in many cases would be panelled. The table generally fits in grooves in the ends and is made to draw out several inches beyond the front. Figure **64** is an end view of the fall. It is pivoted at the centre from which its curve is struck, the connecting pieces generally being of hoop-iron. It is staved up on a block as in **65**, and the staves should be dowelled or tongued as well as glued. The back of table and back of fall are usually connected, so that the fall opens when the table is drawn out and closes when it is pushed in. Figure **66** is another form of roll-top desk with a flexible fall. This is an improvement on the cylinder fall, and is now in more common use. In this the fall slides in grooves in the ends. It is formed by gluing strips of wood on canvas, as in **67**. The pedestals are panelled and connected by a panelled back and by a stretcher in front secured by metal angle brackets. The drawers lock automatically by means of catches which clip their backs. These catches are released by pressure of the fall when it is pushed back as far as it will go. The lock on the fall is of a kind which locks itself when the fall is drawn down, and requires a key only for unlocking. These desks are usually made of oak. The table is solid board screwed directly on the pedestals. A writing bureau is



58. Method of fitting swinging legs **59.** Rule joint **60.** Method of cutting legs to uniform level **61 and 62.** Pedestal desk and detail of top **63.** Carcase of cylinder fall desk **64.** End view of cylinder fall **65.** Cylinder fall built up on a block **66.** Desk with flexible or tambour fall **67.** Section through fall **68.** Writing bureau **69 and 70.** Bookcase and details of carcase **71.** Saw-tooth arrangement for adjusting height of shelves **72.** Wardrobe **73 and 74.** Methods of jointing front and hinging doors **75 and 76.** Cabinets **77.** Method of building up base and top with curved ends **78—80.** Methods of fitting glass in furniture **81.** Frame of a couch **82.** Joints of legs in a central post **83.** Buttons **84—86.** Methods of rounding interior angles **87—90.** Methods of glass-papering

shown in 63. The cover is hinged, and when opened is supported by two slides which draw out from the carcase. On writing-tables with level tops loose desk slopes are often used. These are very simple in construction, sometimes consisting only of a piece of board tilted by two tapered battens screwed to its under surface.

Bookcases. Sometimes these consist merely of an open carcase with shelves, but to keep dust from the books the best cases are fitted with glass doors. A common type of bookcase is shown in 69. In this the upper doors are glazed and the lower ones wood panelled, as there would be some risk of glass getting broken in the latter. The parts are made separate, as in 70, and the lower part is wide enough to project 4 in. or 5 in. in front of the upper, thus providing a useful ledge and being better proportioned for the larger books it is intended to contain. The upper part should have a vertical partition in the middle behind the meeting stiles of the doors. If the length of the shelves exceeds 4 ft. the lower part would be better with a similar partition. The upper part is lap dovetailed at the corners, and the partition housed in and screwed. The lower part has two stretchers lap dovetailed in at the top, and its bottom may be housed and nailed if covered by plinth, or fitted into a dovetail groove and glued, and in either case may be further strengthened by glue blocks in the angle beneath. The front edges of the sides may have pieces glued on to form pilasters, thus giving the sides an appearance of greater thickness than is actually the case. A top is screwed on to the stretchers of the lower part, and the upper part is screwed on to this. The doors of the upper part are hinged on the face of the frame.

Shelves are generally made adjustable in height. A common method of doing this is to screw saw-toothed strips about ⅜ in. thick against the sides, as in 71. Bearers of similar thickness are made to fit between, and on these the shelf ends rest, the ends being notched at each corner to clear the saw-tooth strips. The alternative to this method is to have two columns of holes corresponding with the saw-teeth in the last example, and to insert pins in these to support the shelves. These pins are of metal, and there are several varieties of them.

Sectional bookcases have become very popular and are best where the number of books is constantly increasing. Bookcases like 69 look well as an article of furniture, but they are suitable only for a fixed quantity of books. Sectional cases consist of a number of separate boxes each with a capacity, say, for twenty average books. These sections are all alike and provided with simple means of uniting them end to end or one on top of another. A glass door may be fitted to the front of each section. A convenient arrangement is to hinge the doors at the top, and make them so that when lifted into the horizontal position they can be slid back into the case, leaving the front clear and the books uncovered.

Wardrobes and Cabinets. Wardrobes are a common example of large carcase work. They are usually made in three parts, the plinth and cornice being separate from the body, and these parts fitting together loosely with blocks or dowels as guides, and in some instances screwed together. Figure 72 is an illustration of an ordinary plain wardrobe. It has a drawer at the bottom, and the door in the middle is panelled with a mirror. The sides are lap dovetailed to the top and bottom similarly to the bookcase in 70. In the best work, backs are panelled, but generally matchboarding, ply board, or a number of panels between muntins, as in 86, are put in the back. As the doors of wardrobes do not extend across the entire front, pieces, either panelled or plain, must be put on. In many cases these are nailed or screwed directly on and the holes plugged. Where this is objectionable they are glued and dowelled, or screwed from the inside, and sometimes glue-blocked. Figure 73 shows a joint between front and side. With a drawer at the bottom, as in 72, the parts of a large wardrobe would generally be jointed at the bead above the drawer, and the plinth would generally be solid with the lower part, as in the bookcase [69]. The methods of constructing more complex wardrobes do not differ much from what has already been described. Doors, whether in the middle or at the sides, close against the front edges of the frame, as in 74, which is an example of a door hinged to a side. Drawers in the lower part generally work between pilasters formed as in 70, guides of course being required flush with the pilasters, and the width of the latter representing a corresponding reduction in drawer width, the space behind the pilasters not being utilised. Beads are often formed as in 73, where joints occur on the outer faces of front and sides.

Figure 75 is a cabinet with glass doors, and drawers and table above. Its carcase is framed with bottom, shelf, bearer and runners for drawers, and stretchers dovetailed in at top to screw the table on to, none of which differs essentially from what has already been described. The back portion, which forms the main support of the upper shelf, is panelled and screwed on behind. Figure 76 is another form of cabinet, veneered, inlaid, and decorated with ormolu. It has three doors, the middle one containing a mirror, and the two side ones being curved, with glass panels. The curved rails of these doors might be of solid wood worked to the sweep and veneered, but the best way is to form them of a number of layers of veneer bent round a block and glued together. The base and top may be built up as in 77, and the four uprights which enclose the doors may be halved in flush with the outside faces, and the outstanding blocks put on after.

Glass in Furniture. The ordinary methods of inserting glass are shown in 78 to 80. In 78 the glass drops into rebates and is secured by wood fillets behind. The method shown in 79 is suitable only for mirrors. In this the glass goes into a rebate as before, but is protected behind by a backing of flannel and board, the flannel being flush with the back of the frame, and the board screwed on. In 80 the glass fits loosely in the rebate, and is centred and secured by glue blocks as shown. Glass divided by ornamental bars into a number of panes is fitted similarly to that in ordinary windows, except that wood fillets are more generally used than putty. When these have to be bent to curves they are generally of birch or other flexible wood. Where the bars form a very ornamental pattern they are sometimes merely stuck on the surface of a single sheet of glass. Plain and bevelled mirrors may be purchased in great variety of size and shape, or can be obtained to order.

Miscellaneous. Figure 81 is the frame of a couch. The feet are supposed to be dowelled to the under part of the frame. An alternative is to tenon the rails in similarly to those of a table. The upper parts which form the back and end are tenoned or dowelled and glued in the most convenient way to produce the outline desired. Figure 82 shows the

usual method of fitting the feet of circular tables and other articles into the centre post. Screw heads are sometimes concealed by gluing buttons [83] over them. Three methods of forming rounding interior angles in frames are shown in **84** to **86**. Figure **84** is satisfactory, but involves either gluing on a piece or cutting out from one of the members. Figure **85** is a good method when the parts are mitred. Figure **86** has the advantage of allowing the straight pieces to be planed up parallel.

Glue blocks, as illustrated in Joinery, are very commonly used in cabinet work. In many instances, where widths are not great, they are used across the grain. The union of rails to table legs, for instance, is often strengthened in this way. Wire nails are very often used on exteriors without any attempt at concealment, while in other cases they are punched in and the holes stopped, but their presence can, of course, be detected if they are looked for. Metal connections, such as brackets and thin plates or strips, screwed on, will often make a substantial job of what would otherwise be weak owing to slender proportions of wood or a difficulty in making a sufficiently strong joint between parts.

All parts of furniture that are either ornamental or standard in form may be purchased ready made at not much higher prices than the cost of the material. Thus, prepared and carved panels, pediments, brackets, trusses, plain and embossed mouldings and beadings and pressed wood ornaments, can be more economically purchased than made. All kinds of turned work, such as legs, spindles and knobs, are kept in stock by turners and seldom require making to order. There are also so many designs in inlay available that the cabinet-maker never needs to do anything more than select from them. All these articles may be purchased either from specialists or from large firms that stock all of it.

Glass-papering. On a large scale this, and scraping also, are done by machines. Glasspaper is used first to remove tool marks and other slight inequalities and secondly to make surfaces smooth. It is necessary to rub down with glasspaper after the first coats of varnish or stain have dried, to remove the roughness caused by the raised grain. Surfaces, therefore, have to be glasspapered two or three times in the course of finishing the work, and each time paper of finer grade, or paper that has been worn finer by use, is required. A flat surface is done with the glasspaper, kept flat on a rubber as in **87**, and the direction of the rubbing must be with the grain or the surface will appear scratched. Cork rubbers are best, but often a block of wood is used instead. Rounding surfaces are done with the hand, as in **88** and **89**. Hollows are generally managed similarly, though in some cases rubbers of the correct shape are made. Quirks and narrow places may be rubbed with paper simply folded, as in **90**, or wrapped on a thin piece of wood or metal.

Staining. This is done to improve the colour of soft and cheap woods and make them resemble more expensive varieties. The resemblance, however, is chiefly in colour, for in most cases the grain shows unmistakably what the wood actually is. In staining, any inequalities in the shade of the natural wood are corrected. Some parts are generally lighter or darker than others, and this looks especially bad when two pieces are glued together, and the joint is made conspicuous by a sudden change of colour. This, of course, is avoided as far as possible in selecting the wood, but it is further corrected by applying an extra quantity of stain to light parts to make the colour uniform. This matching of the colour of parts is done more or less in nearly all polished work, even when the natural colour of the wood is supposed to be showing. Stains are sold in liquid form ready for use, and are applied with a brush. Hard woods may sometimes be improved in appearance by having their natural colour darkened. Wood darkens with age, but is done artificially by oiling, by staining, or, in the case of oak, by fumigating with ammonia.

Polishing. This is the usual method of finishing cabinet work. There are several ways of doing it, but by far the commonest is known as French polishing. In this the polish is simply shellac varnish (which is shellac dissolved in methylated spirit) applied with a rubber instead of a brush. In order that the polish may be permanent it is necessary to ensure its not becoming absorbed into the wood surface and losing its lustre. The pores of the wood, therefore, are filled by rubbing in a filling medium to economise time and material in applying the polish. There are many fillers employed, plaster of Paris and whiting being common ones, made into very thin paste with oil, water, or turpentine. The filler should be coloured to suit the wood. After this has dr ed and been rubbed down the process of *bodying in* beg ns.

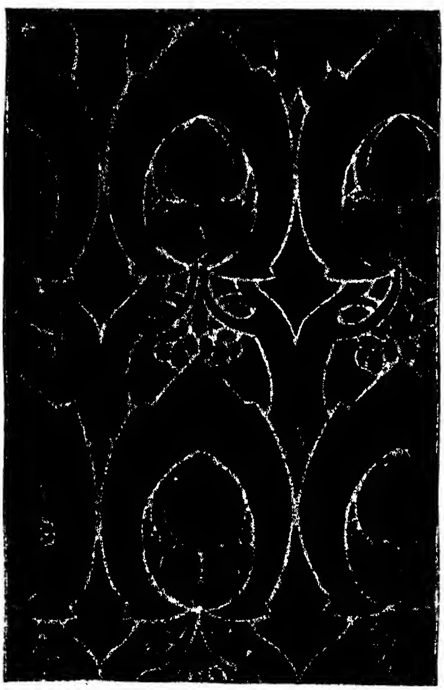
The rubber with which polishing is done is a pad of cotton-wool damped with polish and wrapped in a piece of soft linen rag, one thickness of linen only covering the wool. The polish is rubbed evenly and quickly with light pressure of the rubber over all parts of the surface to be polished. The movements of the rubber are unimportant as long as all parts are treated equally. As the rubbing proceeds, the polish dries and the pressure then may be slightly increased. A little linseed oil is applied to the linen when it does not move freely over the surface, but too much oil will make it impossible to get a good polish. This bodying in should properly be done three or four times, with intervals of several days between each, otherwise it is likely to sink in and diminish the lustre of the polish. The coat of polish should be as thin as possible, to show up the figure of the wood and avoid the yellow colour of a thick coat of shellac. The bodying in is followed by a concluding process called *spiriting off*. In this a very thin polish and finally methylated spirit alone is used to remove oil, smears, rubber marks, and any inequalities. It is, in fact, polishing the surface of the coat of shellac, and, if carried too far, will dissolve and remove the shellac and so spoil the work. The final rubbing should follow the grain of the wood. The pressure should be light and the rubber kept moving. Intricate parts are difficult to polish, and are generally given four or five coats of thin varnish with a brush.

The mediums used in other kinds of polishing are chiefly wax and oil. They give comparatively dull results and are used only for special purposes.

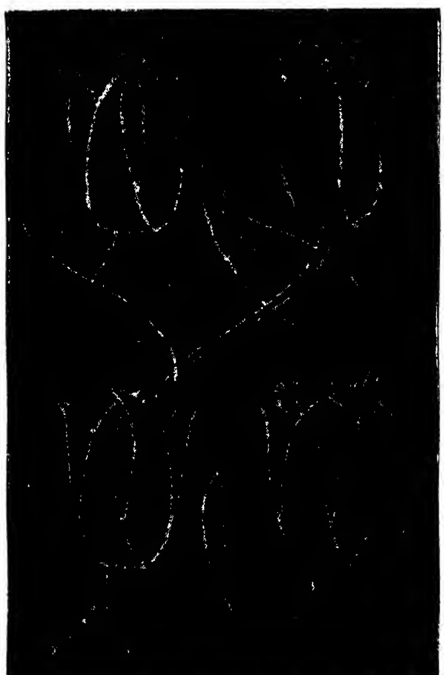
CABINET-MAKING *concluded; followed by* UPHOLSTERY

11. REVERSE DROP REPEAT

12. CHASING AND TURNOVER REPEAT



13. REVERSING SIDE REPEAT



14. CHASING REPEAT

WOOL AND COTTON WOVEN FABRICS: FOUR REPEATS SUITABLE FOR WEAVING

DESIGN FOR WOVEN FABRICS

Pattern Made by Interlacing Warp and Weft. Reversing and Other Repeats. Designs for Madras Muslin, Lace Curtains, Chenille, and Silk Fabrics

By H. NAPPER

TO the designer the amount of different materials and the variety of methods of weaving offer such an enormous field for his invention that it is difficult for him to keep in touch with the changes in production and vagaries of fashion to which the market is subject. Unlike other forms of material that require pattern, such as carpets and printed goods—where there is very little in the way of change in method of production—tapestries, silks, and other woven fabrics are constantly undergoing change in the desire to get different mixtures in wearing so as to give new features to the material and to compete with other firms in producing something new.

The Basic Pattern in Woven Fabrics. The simplest form of woven fabric, which must be made by the interlacing of warp and weft, immediately begins to give texture or pattern. Ordinary matting gives a good idea. There you have the pattern made by the material. This makes designing for woven materials interesting to the craftsman because the design becomes a part of the material, and in some cases the beauties of the fabric must have pattern before they can be seen.

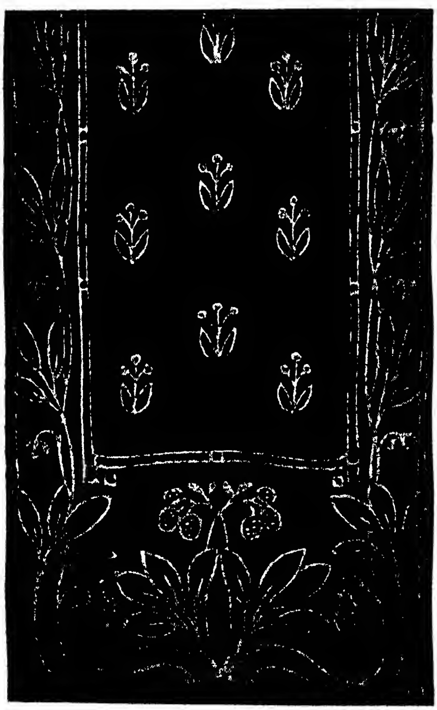
Patterns are made for wool, cotton, polished cotton, silk, satin, chenille, etc., and an endless variety is made, again, from mixtures of one, two and three of these together. The many uses to which these can be applied also make a great demand for variety in style and size of design. It is not necessary for the designer to have a thorough practical or inside knowledge of the way in which these fabrics are woven or to put his productions on to ruled paper, for, with the exception of Madras and the coarser forms of tapestry, the actual drawing can be reproduced with the most delicate forms copied exactly.

Repeats Economical for Weaving. It is necessary to bear in mind that a drawing, even for the finest damask, must be put on ruled paper (before the cards for weaving are cut) inside the factory, so the size of the design becomes a matter of cost in the production, especially regarding the height. There are shown in illustrations four methods of weaving, which give some idea of economy in repeat. The first [11] shows the ordinary "reverse drop." It will be noticed that in the lower right-hand corner is a part enclosed within dotted lines, within which are a few alterations; centre leaves are not the same—a line is introduced across the stem. These things might be done in designing to ease the effect, but to get it would mean that the cost of production would be increased. In 12 is shown a very useful method of weaving. Although this looks like a long pattern, it is really only half of what it seems. When the cloth is woven, say, to the top of the flower, the cards are reversed or turned over, and the pattern runs again the other way. Various names are given to this repeat—"chasing," "turnover," "bosom," etc. A reversing side-repeat is shown in 13, and another form of chasing or side-repeat in 14. These present the only methods of getting large-looking patterns in small repeats. The third is, of course, economical in that it reverses exactly. These repeats apply to almost every form of weaving. There are, unfortunately, no set sizes for widths of design, as in printed papers and fabrics. This makes it difficult for the designer. Some English and most of the Continental manufacturers use 25 in. width, making 12½ in. for reverse, again divided into 6¼ in. Other looms are only used for sizes of 9 in. to 18 in. reverse, thus making material into divisors of yards, similar to carpets.

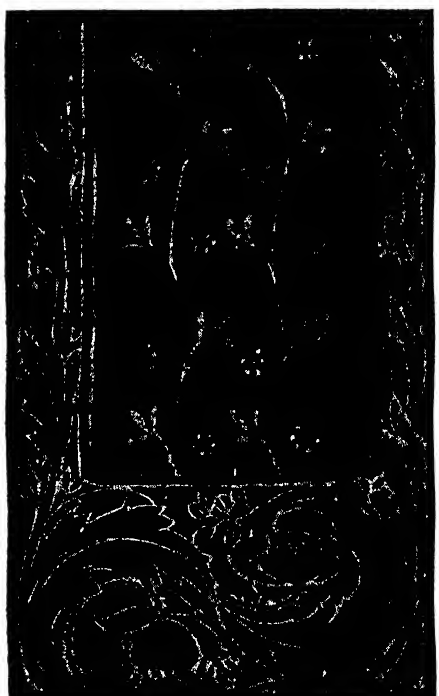
Madras Muslin Designs. The simplest form of weaving for which the designer can start is Madras, or lace muslin. Madras muslin is used for curtains hanging in windows, etc., as for the greater part of the time light is seen through them.. Experience will teach that solid masses should be used sparingly, and if the design contains large objects they should be broken with half tones so that the lightness of the material is not destroyed. In single cover—that is, with ground work woven in fine yarns of warp and weft—with heavy second weft to make the pattern by interlacing with the ground yarns, where this weft is not attached to the ground to make pattern, it is afterwards cut away by means of a clipping machine. Although the effect of this is one colour in white, cream, or ècru, a great variety of effect can be obtained by using the weft in horizontal lines, with ground showing between, or by dots [15]. The more even the weight is the better the curtains will hang. It is not necessary to work the design elaborately with lines; a half-tone wash will show what is intended. Make the design on thick tracing paper or ordinary brown paper, so that the effect is always seen light on dark, and keep the detail large to allow for easy rendering on the ruled paper. In describing this, one warp and two wefts have been mentioned, but the designer need only think of the material as in the one weft or shuttle. The ground is not counted, it being a necessity; merely the net in which his pattern is woven.

Various qualities of this material are made, coarse and fine. Other shuttles are added, making it two, and sometimes three cover. For two, a good way is to use one for outlines

15. DRAWING FOR MADRAS MUSLIN AND EFFECT OF SAME WOVEN

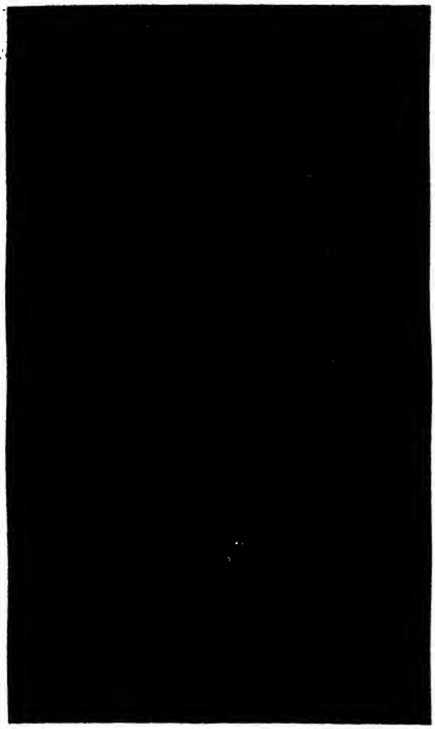


16. LACE CURTAIN—REVERSE DESIGN

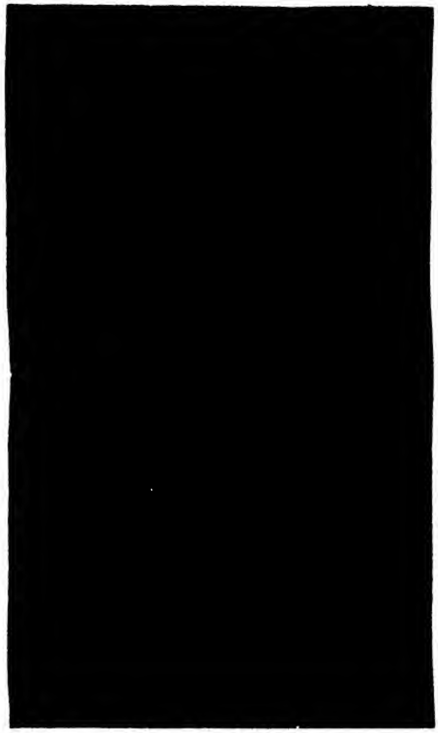


17. LACE CURTAIN—FREE DESIGN

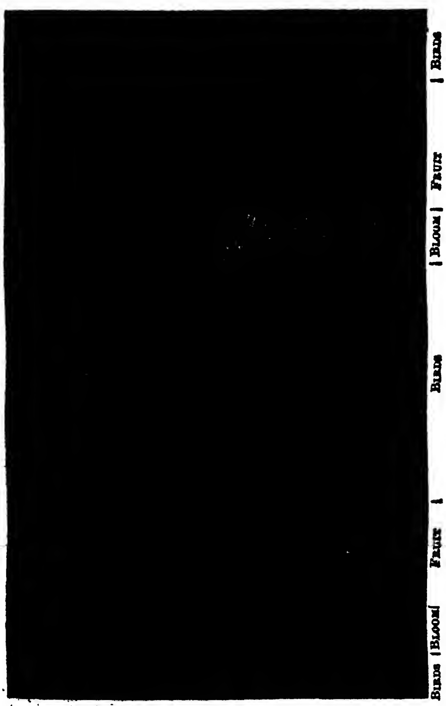
MADRAS MUSLIN AND LACE CURTAINS



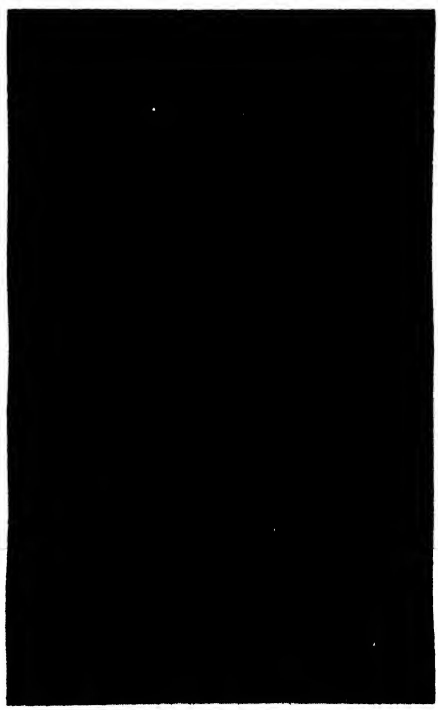
18. EXTRA COLOUR WITH TWO WEFTS MIXED



19. EFFECTS FROM MIXTURE OF WARP AND WEFT



20. WEFT PLANTED



21. WARP PLANTED

MIXTURES AND PLANTING IN WOVEN FABRICS

and half tones, using the second for "chintzing" or "planting" (described later in the heavier fabrics). These can again be mixed, giving a great variety of effects by the use of silk, cotton, and tinsel. Almost any width can be used for the repeat from 8 in. to 24 in., and any reasonable height. Should borders be necessary, keep the same height as for filling or a divisor of same.

Lace Curtains. Curtains allow much more freedom in design than Madras, and also more effects, which are best represented by flake white and washes of various depths on a dark blue or black ground. The great scope allowed is shown in illustrations **16** and **17**, by different borders on either side, free and reverse dados, etc. Almost anything can be represented in this material, as a glance at the various windows in any street will show. The beautiful qualities of hand-made lace do not concern the maker of patterns, as all the woven fabrics described in these articles are made by machinery.

Mixtures and Planting. In nearly all fabrics composed of wool or cotton, generally termed tapestry, the pattern or colour parts are made by the weft, the ground by the warp. This is always the case with the best qualities, and in the English makes. The better the material the easier it is to make designs suitable for showing the beauties of the material. Some rich effects are obtained by the use of two, three, four, and sometimes more wefts; this gives a free use of any of these colours in any way wished, sometimes mixing two together to give extra colours, if required. Of course, every extra weft adds to the cost of production. The weft having to pass at the back of warp when not required in front to make the pattern, gives a heavier and richer effect to the hanging. With a material composed, say, of two wefts and one warp, the richness of appearance can be obtained, with great saving in material and weaving, by changing the one shuttle. Both wefts can be changed if necessary, but it is better to keep one for the building up of pattern, otherwise the colouring becomes too complicated in getting different ranges. By referring to the illustration of weft "planted," it will be seen how, by a little ingenuity in arranging the design, bloom, fruit, and birds can be changed into three distinct colours, and still be counted as only one weft [**20**].

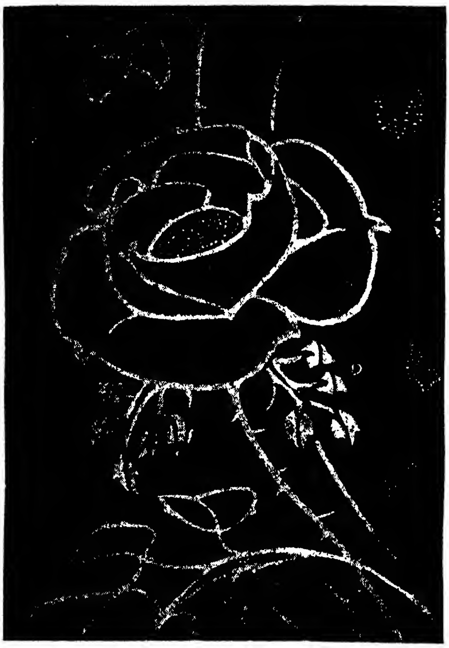
From these, again, other colours can be obtained by the mixing of the two wefts in the way shown in **18**. If a green weft be used for leaves and stem, the turnover part, when in line with the bloom, can be mixed with it, if of yellow colour the green would become lighter and greener; the same would occur with bird and fruit colour. Great care must be taken that only two colours are in a line, and that the colours do not look like bands, unless the design has been made to get this effect, and the ground is the richest or best material. There is a great variety of cloths made in this way, some of very fine quality, others coarse; but the same rules apply where more wefts are used. It is usual only to "plant" or "chintz" one of them, and three to four changes in the length of repeat will be sufficient for all requirements.

Mixtures for Cheaper Materials. In other illustrations [**19** and **21**] will be seen another method of mixtures, the same again combined with planting. This is generally a cloth of cheaper quality, but capable of giving a greater variety of effect, and is useful for coverings and general hard wear, owing to its presenting a harder surface when well made. In this fabric the colours are generally derived through the warps, the wefts in most cases being a black and cream. These are apparently only used for outlines, and should never be in large masses, as they are generally of poor quality. Their great feature is that when used for tying down or mixing with the warps, two effects of colour can be obtained. In examining the illustration **19**, it will be seen that in part of the leaf black lines cross, in another white lines. This explains the method; although the lines are tied, it is not exactly in this way, it being impossible to show in black and white, but it will serve to show how two colours are made. It is not necessary to show either the black or cream in the drawing. Two tints of the same colour, but different weight, and that the mixture with black always gives the best effect in cloth only have to be considered.

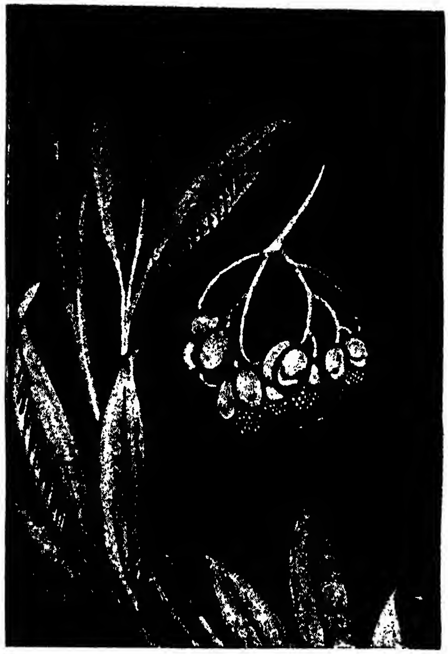
It will be seen that, given three warps and two wefts, eight distinct tones can be used, but the six colours will consist of two shades from the three warps. Sometimes a fourth is added for ground; in this case it is generally of wool, serving to give a richer material. This is used solid, and not mixed to give a double effect with the wefts. Many varieties of this cloth are made with the black suppressed, except for mixing purposes, and the same with the cream. It can also be "planted," as shown in **21**, getting almost endless varieties. The drawing for this should be kept on the large side, as there is a slight straightness or stepped effect when carried into the squares, resembling the effect of Brussels outline.

Silk Wefts and Cotton Warps. A very beautiful and rich material of modern invention is made, in which the wefts are of silk, mixed with warps composed of cotton threads, generally in white and red. These are only perceptible on close examination, but the result given to the fabric is amazing in its variety of colour when folded. The outline is a weft and plays no part in affecting the appearance of the silks. It can, therefore, be made white, black, or any colour the weaver wishes. In the more costly productions chenille is used, adding another contrast in surface. The colour effect is obtained from the floating surface of silk wefts; so if one, two, or three wefts are used, two colours can be made from each by the white cotton coming on to the surface to give the light shade, and the red showing in the other parts to give the deeper shade. With three wefts six colours can be produced.

Chenille. This is a very beautiful fabric of cut pile, composed of fine wool dyed in every conceivable shade. It is used principally for curtains, but sometimes in mixtures with

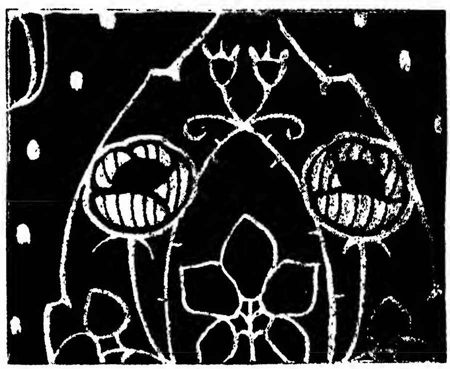


22. SILK WEFT TIED BY GROUND-WARP

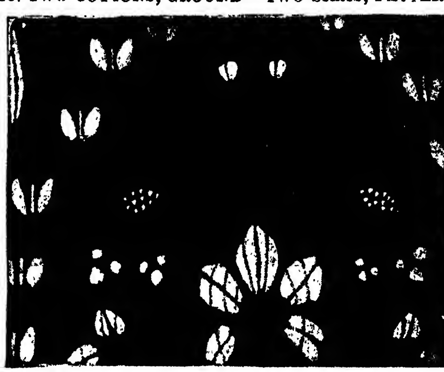


23. DAMASK—SHOWING EFFECTS BY MIXTURE OF WARP AND WEFT

24. BROCATELLE, SHOWING BOLD DRAWING



25. TWO COTTONS, GROUND—TWO SILKS, PATTERN



26. BOTH SIDES OF REVERSING CLOTH

DESIGN FOR WOVEN SILK FABRICS

silks for outlines, etc., in other fabrics. For hangings, it is an ideal material, as it is practically the same in colour and design on both sides. There is no limit to colour or scope in arrangement of design. The same freedom exists as in lace curtains. Unlike any other fabric, there are no technical difficulties in the matter of warps and wefts; the colours are woven on to a continuous weft, which passes backwards and forwards in the width of curtain, falling exactly over each other, and building up the curtain with loops and ties in the warp. The sizes to bear in mind are the widths of curtain, which should always be in yards—from 1½ yd. to 2 yd. in width, and 3 yd. to 4 yd. in length. Borders 9 in. in width, and always repeating in the same height as filling.

Make the design on thick cartridge paper, in solid tempera colours, so that it will bear rough usage when passing through the factory. This advice applies to designing for every purpose. The drawing is looked upon as for a practical purpose, not as a work of art, and in most cases is cut up and marked in such a way that it becomes unrecognisable.

Silks. The most simple and beautiful form of silk to design for is damask. Whether it be made in pure silk (though called silk, it is generally a satin ground) or in polished cotton the result is invariably pleasing. In nearly every case in which the effect is obtained by one warp and weft, the ground is the most expensive part of the material, and should always have the larger portion of the repeat. Mixtures can be obtained by lines or dots of the pattern giving effects of tones from the ground as shown in 23. They need not be carried out in this way, as a wash in the shape required will do; but it must be used sparingly, otherwise it will tend to destroy the brilliancy of the fabric, and the sharpness of the design.

Damask fabrics are used for a great variety of purposes, the finest being for dress material. Some of these are so fine in quality that a line drawn by pencil can be reproduced. In making a design for them it is usual to draw it with pencil on white paper, giving the effect of shading with slight washes of colour. In all silk materials requiring pattern the imagination has to come into service, for it is impossible in the design to give an imitation in any way of the fabric and at the same time make a practical drawing. Coarser qualities are used for furniture coverings, hangings, tablecloths, etc. Widths in general use are 21 in. or divisions up to 31½ in. or 63 in. Care should be taken in regard to height, as even in the finest quality the pattern must be put on ruled paper, as with a carpet, and cards cut and laced together, forming an endless band, the whole of which must be turned over in making a repeat.

Brocatelle and Brocade. This is a heavier fabric than silk damask, backed with a solid substance which gives to it a full or rounded effect. The raised figure or design is in this the richest part of the material. It is usual, therefore, to show but small portions of the ground. The drawing must be bold [24] and keep the quality of roundness so that the richness of the surface is aided. The sizes usually follow those given for silk damask, but, of course, small divisors or small repeats would not give the large effects required, 10½ in. side or reverse making 21 in. or 31½ in. reversing to make 63 in. width.

Brocade is a very elaborate and costly fabric. Many wefts are used to give a great variety of colours and mixtures, and its best form is seldom used, unless for very special purposes, as in some cases only a few inches can be woven in a day, owing to the fineness of material composing the pattern.

Silk Mixtures. A great variety of silks are made with mixtures of silk, satin and cotton. The ground in these, as in the case of silk damask, is always the richest part. A small piece with two silk wefts—one for outline, which can also be mixed with ground, giving half-tone, and the other for colouring the pattern—is shown in 25 and 26. This can be "planted" or "chintzed" when carefully arranged, two, three, and four changes being given to this weft, adding to its variety.

It is necessary for the silk to float or come away from the ground, otherwise the gloss or sheen would not be retained. This cannot be done in large masses without tying them to the ground by the warp in some way, because the silk would fray or get away from its original shape. To obviate this and to keep some of its natural beauty, ties are introduced as shown in 22, about a quarter of an inch apart, which are made by the warp. These must be put into the design, following, if possible, the drawing in the design, helping to give it more expression. Care must be always taken to keep them as near as possible to perpendicular lines in order to cut the weft in fairly equal proportions.

Cheaper Silk Fabrics. The ground can also be planted, if a striped effect is desired, by making on the edges of different colours, a small trailing pattern in the outline weft. This will soften the contrast and give the fabric a lighter appearance. Sometimes three wefts are introduced so that two colours for all-over purposes, and one to change or plant, are obtained. In cheaper qualities cotton is substituted for the cream outline, and if used sparingly gives a very good effect. Owing to the dulness of cotton the silk or satin looks much brighter by contrast. Some silks are made with the patterns showing equally on both sides, but, of course, reversed [see 25 and 26]. For these, like all cheaper forms of silk, it becomes more difficult to make satisfactory patterns owing to the complications in weaving. Generally there are two ground colours, cottons, which dovetail into one another. Outlining and making pattern on these are two silks, which can be mixed with the cotton, giving other effects, serving to hold the fabric tighter, and giving a more varied surface. It is impossible in this cloth to give extra effect by "planting," as what fills in a shape on one side becomes outline on the other. This reversing quality must always be borne in mind.

Continued

THE CHURCH AS A CAREER

The Church of England and Nonconformist Denominations. The Roman Catholic Church and the Jewish Ministry. Examinations and Colleges

THE CHURCH OF ENGLAND

By R. Mudie-Smith

THOSE who wish to become candidates for Holy Orders should apply for entrance into one of the theological colleges of the Church of England [see list below]. Every application is considered on its merits, regard being taken as to the evidence of personal piety and promise of fitness for the ministry apparent in the candidate.

The full course of preparation sometimes occupies three years (or two years if the Central Examination is taken before entering college). Two examinations, the Central Examination for non-graduates and the University Preliminary Examination for Holy Orders, have to be encountered in the course of preparation, besides the personal examination of the ordaining bishop.

Entrance Examination. The "Central Examination" is required by all the bishops before admission to a final course of two years' study in a theological college. It is an entrance examination in the sense that it admits to the beginning of the two years' theological course, but it is not intended to debar candidates from previously entering a theological college for preparatory training.

The following are the subjects of this examination prescribed for 1907 and 1908:

1. Xenophon's Anabasis, Book III.
2. Cicero, De Senectute.
3. Outlines of Scripture History.
4. The gospel of St. John, Chapters I–XII for translation and interpretation.
5. Outlines of English History: Text books recommended—*Outline of English History* and *Oman's History of England* (Gardiner).
6. The first book of Euclid (the paper will include easy deductions), or Elementary Logic or Modern Geometry.

Candidates are exempt who have passed any of the following examinations: (*a*) The Oxford and Cambridge Senior Local; (*b*) Examination for Higher Certificates of the Oxford and Cambridge Joint Board; (*c*) the London University Matriculation, provided that the candidates shall have passed in Latin and Greek; (*d*) Responsions at Oxford; (*e*) Previous Examination at Cambridge, Parts I. and II.; (*f*) one examination after Matriculation in Trinity College, Dublin; (*g*) examinations for the title of Associate in Arts of any of the recognised University Colleges in England; (*h*) Matriculation Examinations in Colonial and other Universities: provided that in all cases the candidate shall have passed in Latin and Greek, and that the certificate of having passed any one of the specified examinations shall have been obtained within three years of the examination from which he desires to be exempted. In examinations which do not include Scripture subjects, the candidate will be required to pass in the outlines of Scripture history and in the selected gospel.

Method of Application. Examinations are held three times a year—viz., in the first week of December, in the second week before Holy Week, and in the last week of July.

CHURCH OF ENGLAND THEOLOGICAL COLLEGES

Name of College.	Terminal charges inclusive: (1) Tuition (2) Board.	Average length of residence required.	Principal.
Chichester Theological College	(1) £35 per annum; (2) £55 per annum	For non-graduates two years. For graduates one year	Rev. Preb. Rickard, M.A.
Wells Theological College..	(1) £30 per annum or £10 per term; (2) £75 per annum	Four terms..	Rev. H. L. Goudge, M.A.
St. Aidan's Theological College, Birkenhead	(1) and (2) resident students £24. Non-resident, £14 per term	Six terms. Three terms for graduates	Rev. A. J. Tait, M.A.
Cuddesdon Theological College	£30 inclusive	Five terms (if possible) ..	Rev. Canon Johnston, M.A.
Lichfield Theological College	In college (1) and (2) £30 per term. In lodgings, £13 16s. 8d. per term	For non-graduates two years. For graduates one year	Rev. Preb. E. Elmer Harding, M.A.
Salisbury Theological College	(1) and (2) £30 per term. Four terms	For non-graduates two years. For graduates one year	Rev. Canon D. Whitefoord, D.D.
London College of Divinity (Highbury)	(1) £10 per term; (2) £45 per term	Non-graduates two or three years. graduates one year	Rev. A. W. Greenup, D.D.
Lincoln Scholæ Cancellarii	(1) and (2) £81 per annum inclusive	Non-graduates two years. Graduates one year	Rev. Canon Crowfoot.
Ely Theological College ..	(1) and (2) £30 inclusive ..	One year	Rev. Canon B. W. Randolph, D.D.
Leeds Clergy School ..	(1) and (2) £27 10s..	One year	Rev. J. G. Simpson, M.A.
Wycliffe Hall, Oxford ..	£25 inclusive per term	One year	Rev. W. H. G. Thomas, D.D.
Ridley Hall, Cambridge ..	(1) and (2) £25 per term	Three terms	Rev. T. W. Drury, B.D.
St. Stephen's House, Oxford	(1) £5; (2) £16 ..	Graduates one year ..	Rev. G. H. Brown, M.A.
St. Michael's College, Aberdare	(1) and (2) £70 ..	Non-graduates two years. Graduates one year	Rev. H. R. Johnson, M.A.
House of Sacred Mission, Kelham	(1) £20; (2) £40 ..	Six years	Rev. H. Kelly, M.A.

Candidates for examination, and candidates who present a certificate of an equivalent examination, must apply through the principal of the college at which they propose to enter or of which they are already probationary members.

These applications must be made on or before November 1st for the December examination, on or before March 1st for the March examination, and on or before July 1st for the July examination. Each applicant must state in his application which of the alternative subjects, Euclid, geometry, or logic, he intends to take.

A fee of 15s. is charged to every candidate, and the fees as well as the application must be sent to the principal of the college. The papers set in previous examinations can be obtained from Deighton, Bell & Co., Cambridge, price 1s. 1d. for each year.

The University Preliminary Examination. The University Preliminary Examination for Holy Orders is taken at the end of the student's complete course. It is conducted under the control of a council consisting of the divinity professors of Oxford and Cambridge, two graduates in divinity from each university nominated by the Archbishop, and examining chaplains, one being nominated by each of the bishops, who accept the results of the examination.

The examinations begin on the Tuesday in the second week before or after Easter which is nearest to April 3rd, and on the Tuesday nearest to October 8th.

The examinations are open to (*a*) graduates of the English universities; (*b*) members of theological colleges in connection with the Church of England who have at least entered on the last term of the complete course and are recommended by the principal; (*c*) any other person who may be nominated by a bishop with a view to ordination in his own diocese.

The examination consists of the following subjects:

1. A general paper on the contents of the Bible.
2. Old Testament: selected portions:
   (*a*) Psalms i.-xli. (for 1907); xlii.-l., lxxiii.-lxxxix. (for 1908).
   (*b*) Northern Kingdom and Amos for 1907-8.

The paper in these books will contain questions on their subject matter, criticism, and exegesis, together with questions on "Introduction." An opportunity will be given of showing a knowledge of the Hebrew text on the set books.

3. New Testament (in Greek).
   (*a*) St. Luke.
   (*b*) Romans.

The paper on these books will contain passages for translation and questions on the subject matter, criticism, and exegesis of the books, together with questions on "Introduction." Candidates will also be expected to show a general knowledge of the Lord's life and teaching as contained in the four Gospels. Passages from English Version will be given to be rendered into the original Greek.

4. (*a*) The Creeds and the Thirty-nine Articles; history text and subject matter:
   (*b*) Apologetics.
5. The Prayer Book: history and contents.
6. Ecclesiastical History:
   (*a*) History of the Christian Church to the Council of Constantinople (inclusive).
   (*b*) History of the English Church from the earliest times to the Accession of Queen Anne.
7. A selected work or works of a Latin ecclesiastical writer (1907), Cyprian, De Oratione Dominica.

A passage will also be set for translation into English from some ecclesiastical Latin author not previously specified.

8. A voluntary paper on elementary Hebrew with passages for translation (1907): 1 Kings xvii.-xix., 2 Kings iv., v.; Amos.

Candidates are required to satisfy the examiners in each of the first seven subjects.

A fee of 25s. is charged to every candidate who enters the examination.

Candidates are required to send in their names with certificates of moral character and particulars of their degrees, or written forms of nomination from bishops in cases where such nominations are required to Rev. Dr. King, Gayton Rectory, Blisworth, R.S.O., before March 1st for the Easter examination and before September 1st for the October examination.

The papers given in previous examinations, with the regulations, etc., may be had of Deighton, Bell & Co., Cambridge and London, and Parker & Co., Oxford, price 1s. each set, or by post on receipt of 13 stamps.

Candidates, in sending in their names, must give a permanent address.

The Student's Expenses. Students at Oxford and Cambridge can, if they are economical, limit their terminal charges in some colleges to £30. The annual expenses, including subscriptions to college clubs, need not exceed £100. The three-year course, consisting of nine terms, would cost, therefore, about £300. The expenses of a non-collegiate student in the universities who is willing to live frugally and who keeps only the minimum residence in each term, can be kept under £55 per annum on an average of the three years. This sum includes university and non-collegiate charges. The course for arts in the B.A. degree at the University of Durham consists of two years of three terms each.

At University College the average terminal charges are £26 5s., and at Bishop Hatfield's Hall £24. The total, therefore, at the former for the two years is on the average £157 10s., and at the latter £144.

The Ordination Candidates' Exhibition Fund aims at helping young men of thoroughly good qualifications whose means are insufficient to enable them to complete what is required for college training. For full particulars apply to Rev. Canon Petit, M.A., 39, Victoria Street, Westminster.

The following is a list of other funds designed for a similar purpose, and the name of the clergy and others to whom communications should be addressed:

The Cambridge Graduates' Ordination Fund. Professor Stanton, Trinity College, Cambridge.

London Clerical Education Aid Society. Rev. H. F. S. Adams, The Vicarage, Streatham Common, S.W.

Cambridge Clerical Education Society. Rev. G. A. Weeks, Sidney Sussex College, Cambridge.

The Elland Society. Rev. Canon Lamb, Clapham Vicarage, Lancaster.

Bishop Clerical Education Society. Rev. P. A. Phelps, 29, Berkeley Square, Bristol.

Dr. Robinson's Exhibitions. Rev. W. Allen, St. Mary's Lodge, Loughton.

The Society of the Sacred Mission undertakes (where necessary) the whole cost of the student's six years' training at their Theological College, Kelham, but students are expected to repay a sum not exceeding £250 by instalments after ordination. There are a large number of applications—over 300 every year—of which only 20 are accepted.

The Bishop's Examination. Persons desirous of being admitted as candidates for Deacon's Orders must make a written application to the bishop three months before the time of ordination. A paper of questions will be forwarded to any person so applying, which he will be required to answer. After due investigation the bishop will fix a time for seeing him. It is not necessary that a person so applying should at the time of his application be provided with a title, which may be sought for afterwards upon the bishop's permitting him to become a candidate.

Candidates for ordination must be under thirty years of age. No candidate can be ordained deacon who has not completed his twenty-third year.

Candidates for Deacon's Orders must supply the following papers:

1. Certificate of baptism.
2. (*a*) If the candidate is a graduate of Oxford or Cambridge—Certificate of his having taken B.A. degree, and also having attended two courses of lectures by divinity professors, one of which must be a course by the Regius professor. (Such certificates are not required if a candidate shows that he has taken honours in the Theological School or has spent a year at a diocesan theological college, or has passed the University Preliminary Examination of Candidates for Holy Orders.)
   (*b*) If the candidate is a graduate of Dublin University—The certificate of his having taken the B.A. degree and also the Divinity Testimonium.
   (*c*) If the candidate is a graduate of Durham University—The certificate of his having taken the degree of B.A. and also the Licence of Theology.
3. College testimonials.
4. Testimonials for the time elapsed since the candidate left college.

Examination for Deacon's Orders. The subjects of examination for Deacon's Orders differ somewhat in each diocese, but the following are the subjects prescribed for the London Diocese, 1907. The books suggested for the course of study are given in italics:

1. The Old Testament:
   (*a*) General knowledge of the contents and interpretation. *Old Testament History* (G. W. Wade), *Old Testament History* (Edersheim), *History of the Jews* (Ottley), *The Cambridge Companion to the Bible*, *The Divine Library* (Kirkpatrick), *Introduction to Old Testament* (G. H. H. Wright).
   (*b*) Subjects for special study: Book 1, Ps. i., xli. *The Psalms, Book* 1 (Kirkpatrick).
   (*c*) The Hebrew Text of Psalms i.–ix. (optional).
2. The New Testament:
   (*a*) General knowledge of the contents and interpretation. *Life and Times of Jesus the Messiah* (Edersheim), *Introduction to the Study of the Gospels* (Westcott), *Introduction to the New Testament* (Salmon), *The Books of the New Testament* (Pullan).
   (*b*) Special subject for study in the Greek text: the Gospel according to St. Luke. *International and Critical Commentary* (Plummer), *Cambridge Bible* (Lias).
   (*c*) Oral examination on the contents of the four Gospels. (The Greek text required.)
3. (*a*) The Book of Common Prayer, history and contents. *Prayer Book Commentary* (S.P.C.K.), *A New History of the Book of Common Prayer* (Proctor and Frere), *Teachers' Prayer Book* (Barry).
   (*b*) Ecclesiastical history. The history of the English Church from the earliest times to the accession of Queen Anne. *The Students' English Church History* (Perry), *History of the Church of England* (Wakeman).
4. The Articles of Religion.
   The Thirty-nine Articles (Bishop Gibson), *The Thirty-nine Articles* (Bishop Harold Browne).
5. Latin.
   (*a*) S. Cyprian, De Oratione Dominica. *Edition issued by G. Bell & Son.*
   (*b*) A piece of English to be translated into Latin.
6. Evidences of Christianity.
   Evidences of Christianity (Ragg), *Manual of Christian Evidences* (Row).

The papers required by a candidate for priest's orders are these:

1. A testimonial from three beneficed clergy similar to that which is required for deacon's orders; but only for the time which has elapsed since the candidate's ordination as deacon.
2. Nomination to a curacy, or presentation to a benefice—unless he be already licensed in the diocese, in which case a nomination is not required.

Examination for Priest's Orders. The following are the subjects of examination for priest's orders for the London Diocese, 1907.

PART I. (Advent and Lent)

1. The Old Testament.
   (*a*) General knowledge of the contents and interpretation. *Old Testament History* (G. W. Wade), *Old Testament History* (Edersheim), *History of the Jews* (Ottley), *The Cambridge Companion to the Bible*.
   (*b*) Subject for special study: Jeremiah. *Cambridge Bible* (A. W. Streane), *Expositor's Bible* (C. J. Ball), *Jeremiah: his Life and Times* (T. K. Cheyne).
   (*c*) The Hebrew Text of Jeremiah xxvi–xxviii. (Optional).
2. Dogmatic theology, based on the Prayer Book and Articles.
   Prayer Book Commentary (S.P.C.K.), *A New History of the Book of Common Prayer* (Procter and Frere), *The Thirty-nine Articles* (Bishop Gibson), *The Thirty-nine Articles* (Bishop Harold Browne).
3. Butler's Analogy.
4. Pastoral work. *Parish Priest of the Town* (Gott), *Self Discipline* (Gibson).

PART 2. (Trinity and September)

1. The New Testament:
   (*a*) General knowledge of the contents and interpretation. *Life and Times of Jesus the Messiah* (Edersheim), *Introduction to the Study of the Gospels* (Westcott), *Introduction to the New Testament* (Salmon), *The Books of the New Testament* (Pullan).
   (*b*) Subject for special study in Greek text: the Epistle of St. Paul to the Romans. *International and Critical Commentary* (Sanday and A. C. Headlam), *Cambridge Bible* (Moule), *Practical Exposition* (Gore).
2. Ecclesiastical history. The history of the Christian Church to the Council of Constantinople. *The Student's Ecclesiastical History*, *History of the Christian Church to* 461 (Foakes-Jackson), *History of the Christian Church* (Robertson).

3. Hooker's Ecclesiastical Polity. Book V.
4. Foreign Missions (Bishop Montgomery), published by Longmans.

The Declaration. The following declaration must be made and subscribed, and oath taken and subscribed, by all persons who are to be ordained deacon or priest:

"I, M. N., about to be admitted to the Holy Order of ——, do solemnly make the following declaration: I assent to the Thirty-nine Articles of Religion, and to the Book of Common Prayer, and of the Ordering of Bishops, Priests, and Deacons. I believe the Doctrine of the Church of England, as therein set forth, to be agreeable to the Word of God; and in Public Prayer and Administration of the Sacraments I will use the Form in the said Book prescribed, and none other, except so far as shall be ordered by lawful authority.

"I, M. N., about to be admitted to the Holy Order of ——, do swear that I will be faithful and bear true allegiance to his Majesty King Edward, his heirs and successors, according to law. So help me, God."

Every clergyman about to be licensed to any curacy has to take the oath of canonical obedience to the bishop, and make the Declaration of Assent.

The Oath of Canonical Obedience. "I, A. B., do swear that I will pay true and canonical obedience to the Bishop of ——, and his successors, in all things lawful and honest. So help me, God."

Lectures. The bishop requires deacons during their diaconate to attend courses of lectures, of which they will receive notice. The bishop also desires that the younger clergy in the diocese should attend.

THE JEWISH MINISTRY

By Nathaniel Lazarus

The Jews occupy a singular position amongst the nations of the world. They have no official national government of their own. Their only recognised heads are the ministers of their ancient congregations, who are also in many cases the most prominent leaders of the community. It is, therefore, by no means surprising to learn that the Jews pay special attention to the training of their ministers. Above all, no Jew would tolerate a clergyman who, in respect of his religious and moral life, could be regarded as unfit for his post.

Course of Training. Candidates for the Jewish ministry have more than one course of study open to them. The various methods of attaining their object in view generally depend on their age and opportunities. The chief theological seminary for Jewish ministers in the United Kingdom is undoubtedly the Jews' College, of which the Chief Rabbi is president; 99 per cent. of the Jewish ministers in England were trained at that college.

The college course consists of three distinct divisions—preliminary, junior, and senior.

Candidates for the preliminary class must be fourteen years of age, and pass an *elementary* Entrance Examination in two secular subjects (modern language, or mathematics, or science, or Latin), in English and in Hebrew and theological instruction. The course of study in the preliminary class is so arranged that pupils, on leaving it, attain the grade of the Matriculation Examination of the University of London and of the first theological college certificate. On passing that stage successfully, candidates join the junior class of the college. During that period of their training the students are attached to the Faculty of Arts at University College, University of London, where they pursue an internal course, reading for the B.A. Honours degree in Semitics. At the same time the students are required to attend a series of lectures in Hebrew and religious knowledge at the Jews' College, for the purpose of enabling them to pass the Second Theological Examination.

On completing the intermediate course, candidates devote themselves entirely to the study of Semitics, Arabic, Aramaic, Syriac, homiletics, theology, Jewish history, and literature. At that stage they attain most of the knowledge they ultimately require in discharging their duties as ministers. The curriculum nominally extends over two years, at the end of which successful candidates obtain the B.A. degree and the third theological certificate. The title of Associate of Jews' College is granted to such students.

With those qualifications in hand, candidates are generally regarded fit for the ordinary work of a minister, provided they are not too young. The age of twenty-five is considered to be a reasonable one for beginning duties.

The Diploma of Rabbi. Ministers who decide on entering communal life at that stage postpone for an indefinite period their chances of promotion. Though in possession of the third theological certificate, they have yet to work for the greatly esteemed and extremely valuable Rabbinical diploma. Ministers in possession of an English University degree and of the above-mentioned diploma are assured of successful careers. A special class is attached to the Jews' College for the preparation of students for the Diploma of Rabbi. Before entering that class students must have passed the third theological examination, together with the degree examination of some recognised university. The course of study in that class comprises Talmud and Responsà. It extends over two and a half years. The examination for the diploma is a very strict one, and it is conducted by the greatest Jewish authorities in this country. The title of Fellow of Jews' College is granted to successful candidates.

Scholarships. The Jews' College not only charges no fee for the education received within its walls, but it also bears the cost of the course at University College. Students are, however, expected to use their own books. There are about ten valuable scholarships attached to the college in support of the poorer class of students.

Needless to state, students are not restricted to starting their course of study in the preliminary class. They can join the junior or senior classes on passing the necessary examinations.

A few valuable scholarships are given to graduates of English universities in possession of the third theological certificate who wish to continue their studies at famous Continental seminaries. During that period of their study students can also avail themselves of this opportunity to obtain the German Ph.D. degree, which is a very good qualification for an Anglo-Jewish minister. Though they are often called upon to sit in the Beth-Din (Jewish law court), where various disputes are settled in the light of Jewish law and custom, very few ministers have found it expedient to read for the LL.B. degree, London.

Those who enter on the career of a minister when they are advanced in years must make every effort to pass the Third Theological Examination and to obtain the B.A. degree as soon as possible. Such students may also find it expedient to go abroad in order to obtain a rabbinical diploma from foreign rabbis. They can afterwards return to England as fully qualified ministers. It may prove

interesting to note the fact that such a diploma is almost essential for ministers in the Jewish districts of the East End of London and other foreign communities which are not so much in need of university graduates.

Aria College (Portsea, Hants) and Judith Montefiore College (Ramsgate) are two other theological seminaries conducted on the same lines as the Jews' College. At the former, preference is given to Hampshire men. Young ministers, as a rule, start work in a provincial town. Eventually they make every endeavour to receive an appointment at one of the more famous West London congregations. There are, however, a few exalted posts to which many a Jewish minister looks forward. Such are the positions of Chief Rabbi, Haham of the Spanish and Portuguese Jews, and Dayan (judge) of the Beth-Din (law court). The work of a Jewish minister can be divided into two distinct parts—congregational and charitable. He has to deliver sermons on Saturdays and all other important occasions. He is, to a certain extent, responsible for the religious and moral spirit of the members of his synagogue. He is also expected to take an active part in the charitable and communal affairs of the district under his care. In connection with his latter duties there is a ministers' committee which regulates their work in the East End of London.

The duties of a Jewish minister entail a great deal of very hard work.

THE ROMAN CATHOLIC CHURCH

By Henry Brassill

People outside the Catholic Church do not, in many instances, realise the solemnity attaching to the dignity of a priest. By his spiritual subjects the priest is recognised as the Lord's Anointed.

One would cease to be a member of the Church without formal excommunication if he did not believe in the doctrine of the Real Presence, and the chief reason for peer, as well as plebeian or peasant, for saluting a priest after the manner of a gentleman saluting a lady is that the passing clergyman may be on a sick call and have in his possession the Adorable Sacrament. There is another reason why Catholics pay public respect to a priest—viz., that he is empowered to consecrate, to adjudicate in the tribunal of penance and to discharge other sacred functions.

It is indeed an arduous trial for young or old to be raised to the sacred office. When we use the words "young or old," we mean that age is no impediment. Cardinal Manning had been an archdeacon of the Church of England and a married man before his future Eminence "went over to Rome"; the late Rev. Lord Thynne was father of the Dowager Countess of Kenmare, and officiated at the marriage of his grandson, the present earl, with the Hon. Miss Baring. Cases of this kind may be multiplied. We can name twenty priests in and around London who had been Anglicans, some by profession medical doctors, some military officers, and others who might have made their mark in the professions of which they were originally members, but the call to the sacerdotal office having come, they loyally obeyed, and are at this moment ideal workers in the vineyard.

Newman, the author of "Lead, Kindly Light," was a great Anglican divine; the late Dr. Luke Rivington was a Cowley Father and a strong Freemason; Father Fletcher, son of a baronet, now Master of the Guild of Ransom, was an Anglican clergyman; Monsignor Walter Croke Robinson, a present day preacher of fame, was at one time an Anglican clergyman also, but all had had to take the usual steps to qualify for the Catholic ministry.

The Priest's Oath. To do this it is essential that the candidate, before entering college or house of study, is prepared to make a solemn oath or vow with regard to celibacy. If going in for one of the monastic orders he has to take the triple vow of poverty, chastity, and obedience. Every nun does likewise, and some Orders are very strict with regard to the creature comforts of their members.

There is no distinction of class as to the eligibility of the aspirant to the sacred office, but persons born out of wedlock are objected to. This is especially the case in Ireland, which verily is the cradle of the bulk of English-speaking Catholic clergymen.

The great college of Maynooth has, perhaps, turned out more priests from its hallowed walls than any other. In order to enter, there is held yearly in each diocese a concursus, at which the aspirants are examined in Latin, Greek, and English. The examiners are divines of learning and erudition, and the candidates are dealt with according to merit. There are also colleges at Thurles, Carlow, Waterford, and numerous seminaries throughout Ireland, not the least of which are St. Brendan's, Killarney; Holy Cross, Tralee; St. Michael's, Listowel; and Blackrock, Dublin.

All over the world care is taken that the future priest shows a vocation for the sacred calling. With rare exceptions in Ireland the aspirants start at an early age. The intending secular priest remains all the year round, with the exception of a short holiday, in his *alma mater*. This is also the case of students in English colleges, but many in this country are fully fledged, staid men who know a great deal of the world before they resolve to embrace the sacerdotal calling and enter Stonyhurst, Oscott, or St. Edmund's. Students for the religious orders such as Franciscans, Dominicans, Servites, Carmelites, Prémontré, etc., pursue their course in their respective houses of study until pronounced eligible for Orders.

Cost of Training. The education of a student entering Maynooth College costs some £600, but those by ability who pass into the Dumboyne Establishment get through at a considerably lesser figure.

Another great ecclesiastical college in Dublin is that of All Hallows. It is situate at Drumcondra, and year by year sends to foreign parts, such as Mill Hill, London, priests for missionary service. All Hallows men may be found all over the globe. The pension, or collegiate fee, is considerably less than that of Maynooth, and when the student decides where to carry out his ministrations, in Australia or other distant lands, the bishop of the particular diocese which he selects to be attached to contributes largely to his expenses—in fact, he pays his college fees.

But the most expensive college in the world is that known as "The Pontifical Roman Seminary," in the Eternal City. Only Italian students are admitted to it, as it is the great seminary for the whole of the country. There are minor colleges, but Italian students are never considered to have completed their education without spending a time in the "Pontifical Seminary." A student may be ordained after twelve years' study in this establishment, during which time he may qualify for degrees such as D.D., Ph.D., LL.D., etc. Before getting a degree one must be at least three years in the college, and he must win his laurels by hard work and study.

The Priest's Salary. The salary of a priest both in Ireland and in England is merely nominal. His emoluments in this country, as a rule, are not on a par with a boy's wages. Many have private means—we are alluding to seculars—but the majority are gentlemen who possess little more than the raiment upon them, and who care nought for the world's goods.

The religious orders, or communities, should, perhaps, be referred to. The noble work of the Franciscans, say at Peckham and Forest Gate; the Dominicans at Haverstock Hill; the Servites at Fulham; the Canons Regular of Lateran at Stroud Green; the Passionists at Highgate; the Jesuits at Farm Street and Stamford Hill (Father Bernard Vaughan, S.J., and Father Donnelly, S.J., being perhaps the two most prominently before the public just now); the Salesians at West Batersea, cannot be overrated, and is something difficult to describe if not to conjure with.

Priests live in London from, as it were, hand to mouth; they have consecrated their lives to their duties, and go to their graves penniless—that is to say, they have no money at their death to will away.

Take the case of the *Soggarth Aroon*, who spends his life in Ireland. Often he is summoned in the middle of the night to attend a sick call in a mountain home, miles away. He leaves his bed, goes to the sanctuary where the Blessed Sacrament is reserved, takes the sacred species with him, and, regardless of the dangers of hill-side passes, finds his way to the humble cabin in which a poor soul is throbbing for solace so as to fittingly prepare to appear before its God.

Speaking of Ireland, the clergy hold what they call "stations" twice a year; they are generally held in the homes of the well-to-do. This is a very old custom, and the object is to enable the aged, infirm and feeble generally to comply with the obligations of the Church by going to confession, assisting at Mass, and receiving the Bread of Life. Lent and Advent are the periods of the year when the "stations" are held, and the results are fruitful. An improvised altar is erected at which the service takes place.

A Catholic ecclesiastical student undergoes severe examinations. Humanity, rhetoric, philosophy, logic, and theology, stare and confront him as he leaves the preliminary school before venturing to face the ordeal of being examined in the minor subjects. He is taught in a seminary or a private school before venturing to appear in the presence of the Board of Examiners, and in the event of being successful—"getting a place," as it is called—he enters, say, Maynooth College. Here he studies, and in some four years receives Tonsure and Minor Orders. All well, in a year, he receives Full Minors; a year later he is raised to the sub-Minor. Twelve months after he is raised to the subdiaconate, and possibly another year may roll by before he is made a deacon. The conferring of the Order of the Priesthood, as a rule, follows immediately that of the diaconate, although in some instances students receive the three orders—subdeaconship, deaconship, and priesthood—in the same week. The reason assigned for this is that once a candidate is raised to subdeaconship he has to read his Office, which occupies two hours each day—a rather severe strain upon some who have to study very hard during the remainder of their course. The recital of the Office is obligatory, and a divine is only excused from complying with the mandate in case of illness.

After being raised to the priesthood the newly ordained is immediately sent to work. His rector or P.P. is a reverend brother of experience and mature years. The curate's "salary," if such it can be called, is barely sufficient to provide for clothing and holiday money.

The newly ordained priest says precisely the same Mass as the Holy Father who is supreme head of the Catholic Church. The writer has been in five different countries outside his own, and has had the privilege of attending Mass in each—even on the high seas he has assisted at the Holy Sacrifice—and no matter what the nationality of the officiant or celebrant was, the service was exactly the same as that which in the days of his childhood the writer assisted at in the little chapel at Irremore, County Kerry.

Chances of Promotion. Promotion is very slow in the priesthood everywhere. But a humble curate may be raised to the dignity of bishop. The present occupant of the See of Limerick—Most Rev. Edward Thomas O'Dwyer—was not even a parish priest when the crozier and mitre of his illustrious predecessor, Most Rev. Dr. Butler, were placed in his hand and on his head. The chapter in each diocese in England nominate three ecclesiastics, whose names are placed on what is called the *Terna*, and submitted to the Holy See. In Ireland the parish priests meet, and, as is the case all over the world, Mass of the Holy Ghost is celebrated. After, this the chalice used at the Mass is placed upon the altar. No one is present except those entitled to vote, and the cathedral, or pro-cathedral, doors are barred. In England each member of the chapter, and in Ireland each parish priest, writes the name of the cleric whom he believes to be fitted for the distinguished office. The archbishop of the province presides, and two scrutineers in his presence count the votes.

Three names are sent to Rome, the one having the highest number being described as *dignissinus;* the second, *dignor*, and the lowest, *dignus*—most worthy, very worthy, and worthy. The Sacred College, as in the case of the late nominations for the bishopric of Southwark, may appoint one who was not on the *Terna*, so that elevation or promotion cannot with safety be predicted by anyone.

CONGREGATIONAL AND BAPTIST CHURCHES

By R. Mudie-Smith

A candidate for the Congregational or Baptist ministry must be a member of some church belonging to the denomination, and must have completed the sixteenth year of his age. Upon applying for training to one of the theological colleges he is required to adduce the testimony of one or more ministers and of the church with which he is in fellowship to his consistent piety, mental ability, and general fitness for the work of the ministry. A general statement is also required from the candidate as to his previous history and the chief books he has read, giving his exact age, the nature of his education, his business or profession, and the period of his church membership. Other requirements are a full statement of his theological views and one or two written sermons of his own composition.

The Entrance Examination. The entrance examination includes the elements of classics, mathematics and Scripture history, and the following may be taken as a guide to the subjects prescribed:

Division I.

1. General knowledge of Scripture.
2. Knowledge and use of the English Language.
3. Preaching ability, so far as it may be tested by a sermon to be written on a given theme.
4. Speaking power, voice, etc.

DIVISION II.

1. Latin: Cæsar, de Bello Gallico, Book V., cc. 1 to 27; Macmillan's Shorter Latin Course, by A. M. Cook, M.A.

2. Greek: Xenophon, Anabasis, Book II., cc. 1 to 3; Smith's Initia Græca (any edition after 1898); Exercises 1 to 50, with the grammar of the whole book. Accuracy in Latin and Greek Grammar is essential.

3. Mathematics: Charles Smith's Arithmetic (Cambridge University Press); J. M. Wilson's Elementary Geometry (Macmillan), Book I., to page 80, with exercises.

There is also an oral examination before the College Council. This is directed chiefly towards finding out what the candidate is rather than what he knows, and testing his ability to express his views on Scriptural and theological subjects, and on other subjects relating to the work of the Christian ministry.

The Student in College. A successful candidate enters the college as a probationer. At the end of six months or sooner special reports of his work and progress are made to the committee. If these are favourable, he is then received as a student for the usual course, subject always to the receipt of satisfactory reports. The term of study is from four to six years. The curriculum is divided into a literary course of two or three years, and a theological course of two or three. In cases where a student has taken a university degree the first term is dispensed with and the student admitted at once to the theological course.

All students receive a free education with use of rooms, and, when necessary, free board. It is expected, however, that the cost of board be met wholly or in part by the student or his friends where practicable. There are also a number of scholarships open to competition, by means of which a student of promise may obtain a sufficient income to defray the whole cost of his college training.

Candidates seeking admission into colleges now recognised as university schools, and marked in italics in the list on the last page of this article, are required to matriculate that they may be registered as internal students of the university, and pursue the course prescribed for graduation in divinity. Candidates should matriculate, if possible, before entrance; if not, they must pass this examination at the end of their first, or at the latest their second. session.

The Intermediate and Final Examinations. After matriculation a year's work prepares for the intermediate examination for the B.D. degree, the subjects being Hebrew, Greek Testament, classics, psychology and ethics.

The *final B. D.* requires a two years' course, and comprises these subjects:

1. Hebrew, with Old Testament exegesis and introduction.
2. Biblical Greek, with New Testament exegesis, introduction and textual criticism.
3. Systematic theology.
4. Church history.
5. Philosophy of theism (apologetics).
6. History of religions.

THE WESLEYAN METHODIST CHURCH

A candidate for the ministry must be a baptised member of the Wesleyan Methodist Church, and a fully accredited local preacher. The first stage of his candidature is the vote of the March quarterly meeting of the circuit in which he resides. He must be nominated at the meeting by the superintendent; and if he has not resided for two years continuously in his circuit, the superintendent must present to the meeting a written report concerning him to cover the previous two years.

An untrained man of twenty-five or over is not likely to be accepted unless there be evidence of quite exceptional ability. Still more is this the case with married men, since they cannot be sent to the Theological Institution. In the rare cases where married men are accepted a financial guarantee must be forthcoming, since such a minister would receive only the income of an unmarried man until the four years of his probation are completed, and no children born before that time are chargeable on the connexional funds.

The Church takes no responsibility for the maintenance of a candidate until he has been accepted by the Conference. It is therefore important that he should not give up his employment until after Conference. Moreover, it must be understood that every accepted candidate supports himself to the best of his powers while at the institution. The charge for maintenance there is £30 a year, and for education, £35. If unable to pay these two charges, the candidate must, before acceptance, sign a declaration to this effect, to be counter-signed by his parent or guardian, and his superintendent, promising (*a*) to meet the maintenance charge, or (*b*) to pay some defined part thereof, (*c*) to find himself in clothes and books—the latter condition being assumed in the other classes. Should he be unable, through poverty, to make even the last promise, he must apply for a grant—which will not exceed £10 a year—to meet the expenses.

The Conference expects to be satisfied on certain points before accepting a candidate for the ministry: Firstly, that he believes himself called by the Holy Spirit, that his preaching has been owned of God, and that his personal character is high; secondly, that he believes and preaches the doctrines of the Wesleyan Methodist Church; thirdly, that he has competent abilities and health for the work.

Preliminary Examinations. The candidate's first examination, known as the preliminary, is elementary in character, and takes place about the middle of April. It consists of two parts:

(1) A paper on the English Bible, requiring a general knowledge of Scripture history, and of the nature and contents of the Old and New Testament.

(2) An English paper, in which simple questions in grammar, geography, history and arithmetic are set, and also a short exercise in English composition.

Those candidates are exempt from the literary paper who have passed the entrance examination of any university in the United Kingdom, or the Oxford or Cambridge Senior Local Examination, or obtained the King's scholarship as candidates for admission into a training college. No candidate is on any ground excused the preliminary examination on the English Bible.

The candidate who has been recommended by his circuit Quarterly Meeting will be duly informed by the chairman of the district as to the time and place of the first trial sermon, and of his oral examination before the Synod. The sermon is preached in the presence of three ministers of the district, and a written report of the service is presented by these ministers to the Synod.

Oral Examination. The first of the candidate's oral examinations takes place in the presence of the ministers of the Synod during its sessions in May, and the questions put will test his acquaintance with the main features of Christian theology. When the vote of the Synod has been taken, if the candidate has passed, he is informed of the arrange-

ments made for his second trial sermon. He is also informed of the date by which he must send up his MS. sermon to the General Examination Secretary.

Final Examination. Further examinations await the candidate during the second or third week in July. These take place at one of the theological colleges, where the candidate is accommodated for two or three days. Two papers, consecutive upon the preliminary papers, are now set, the first of which bears on Christian doctrine and knowledge of the leading truths of evangelical theology as taught in the Methodist Church. The second paper embraces subjects of general education.

During this time the candidate appears before a select committee of ministers for an oral examination, to test his ability of expressing his views on general, scriptural, and theological subjects.

From this committee the candidate's case is formally remitted to the Conference, which meets a few days later, for final decision; and if accepted by the Conference, the candidate is sent in the September following his acceptance to one of the theological colleges of the Church for three, or in some cases four, years' training. The distinctive studies proper to the direct work of the Christian Methodist ministry occupy the chief place in the student's attention; but facilities are also provided for pursuing a university course, if this is considered desirable.

THE PRIMITIVE METHODIST CHURCH

A candidate for the ministry of the Primitive Methodist Church, if not a minister from another community, must be a regular member and a local preacher of at least twelve months' standing. If under twenty-one years of age, his parents or guardians must give their consent to his becoming a minister.

If the candidate is a minister from another community, he must be a member of the Primitive Methodist Church for at least twelve months prior to his application, unless proof be given that he is specially useful in the conversion of sinners, and that he has fairly and honourably resigned his connection with the ministry to which he formally belonged.

No candidate must be recommended by the station with which he is connected "unless his constitution is sound and healthy, his piety unquestionable, his mental powers good, his temporal circumstances unembarrassed; nor unless he is of industrious habits, and will use prudent and successful efforts to save souls." The station must also carefully examine him concerning his views of Christian doctrine, reading and writing, and his knowledge of English grammar, history, geography, arithmetic, theology, Church history, evidences of Christianity, and the history and polity of the Primitive Methodist Church.

If such examination be satisfactory to the Quarterly Meeting, the candidate will be recommended to the Secretary of the Candidates' Examining Committee for further examination.

Oral Examination. The Oral examination is held at one of the three following centres—London Leeds and Birmingham. The examiners, time and place of examination, are arranged by the Candidates Examining Committee, appointed by the conference.

The examination is divided into four sections:

1. Reading aloud a passage selected by the examiners.
2. Writing a paragraph from dictation.
3. English grammar, geography and arithmetic.
4. Questions as to the conversion of the candidate, present Christian experience, call to the ministry, his knowledge of experimental theology, the history, doctrines and polity of the Primitive Methodist Church, his methods of study and preparation for the pulpit, of pastoral work and visitation, dealing with penitents, the conduct of religious services and the holding of official meetings.

If successful in the oral examination the candidate must conduct a public service and preach before the district representative on the Candidates Examining Committee, with the chairman of the district meeting and the General Committee delegate. The candidate must also attend the district meeting for the purpose of taking the written examination.

Written Examination. The written examination consists of these subjects:

1. *English Grammar:* Oxford and Cambridge (Gill's series).
2. *Arithmetic:* Pendlebury's up to p. 3369, omitting the following chapters: XVI., XXXV., XXXVI., XL., *e* to *k*, XLI. to XLVI.
3. *English History:* Ransome's "Short History."
4. *Theology:* J. R. Gregory's "Theological Student," and Wesley's twelve sermons, called "The Marrow of Methodism."
5. *Christian Evidences:* Prebendary Row's "Manual of Christian Evidences."
6. *Ethics:* W. T. Davison's Fernley Lecture, "The Christian Conscience."
7. *The History and Polity of our Church:* H. B. Kendall's "Short History," and "Handbook of Church Principles and Polity," the "Consolidated Rules and Deed Poll of the Connexion."

The total number of marks for the whole examination is 900; 100 for each of the seven subjects or books, 100 for the oral examination, 50 for the preached sermon, and 50 for the written sermon. The minimum for the reserve list (candidates for the ministry not applying for a college training) is 725 marks, for the college list, 630.

The written examination begins at two o'clock on the Tuesday preceding the District Meeting.

Each candidate must supply a written sermon, which must be signed by the president and secretary of the Quarterly Meeting, and sent, along with the recommendation from the December Quarterly Meeting, to the Secretary of the Candidates Examining Committee. This will be valued and marked by that committee.

Candidates who pass successfully either for the college or the reserve list, but who have neither been appointed to a station nor received into college, must attend the ensuing District Meeting for examination upon their labours and studies during the year. Should any candidate on the college list wish to take the written examination at the district meeting with a view to improving the position gained by him at the previous examination he is at liberty to do so; otherwise he must take his place on the college list, according to his number of marks.

Candidates who have graduated in arts or matriculated at any of the universities in the United Kingdom shall be exempt from taking English grammar, history and arithmetic. For the remaining subjects they must gain 475 marks for the reserve list, and 400 for the college list.

There is a scholarship (the Lamb Scholarship) which secures the advantage of the college course of training for young men who are unable to pay the usual fees and whose parents or guardians cannot assist them to do so.

THE PRESBYTERIAN CHURCH OF ENGLAND

Candidates for the ministry of the Presbyterian Church of England are not in ordinary circumstances received into the theological college until they have completed their preparation for entering on the study of theology by graduating in arts at some recognised university. With a view to assist men during the undergraduate years, a number of scholarships have been at various times founded by the generosity of benefactors. Men who have thus prepared themselves at some university are admitted to the theological college, Westminster College, Cambridge, after examination in the beginning of October in each year.

The Course of Study. The minimum curriculum of study in the college extends over nine terms or three academic years. At the beginning of each year of attendance two scholarships are awarded to students obtaining honours in the October examination. When required, pecuniary assistance of a limited amount may also be obtained in the form of "Barbour Exhibitions," also a certain number of "Hewley Bursaries" of the annual value of £40.

The college is residential. The fee of £15 per term covers all the expenses of a student for residence, board and tuition with the exception of some small extras, which together need not amount to more than £2 per annum.

Every candidate for admission is required to send his application, with the following certificates, to the principal, not later than July 31st.:

1. A certificate that he is a member of the Church of Christ in full communion.

2. A certificate of character from the minister of the congregation of which he is a member.

3. If he be a candidate from the Presbyterian Church of England, a certificate that he has satisfied his presbytery respecting his motives, religious character, and probable usefulness in the ministry. If he be a candidate from another Presbyterian Church he is required to produce such a certificate from his own presbytery as will satisfy the board of examination on the matters specified in the regulation.

4. A diploma of Master or Bachelor in Arts from chartered university of approved standing. Candidates who have completed that attendance at a university which is required for the graduation, but have not taken their degree, may be admitted to the entrance examination on satisfying the board respecting their reasons for non-graduation.

A candidate who has not completed that attendance at a university which is required for graduation must make special application to the board of examination through the principal. The application should contain a full statement of his case, with evidence of his qualifications for Christian work or of his success in preaching the gospel. The board will inquire into the exceptional circumstances, and the reason assigned for seeking admission, and has power, should it be satisfied, to admit the candidate to the entrance examination, subject to the confirmation of the college committee.

The Entrance Examination. The examination comprises the following subjects:

1. Latin.
2. New Testament Greek.
3. Mental and Moral Philosophy, including logic.
4. Elementary Hebrew grammar.
5. The English Bible; also a short essay on a biblical subject.

Graduates in arts who are not competing for a scholarship will be exempted from examination in those of the above subjects included in the final stage of their degree examination.

THE UNITARIAN CHURCH

The colleges at which students for the ministry of the Unitarian Church may receive their training exist for the purpose of promoting the study of religion, theology and philosophy without insisting on the adoption of particular doctrines.

The chief college is Manchester College, Oxford, and the full course is three years; but the committee may admit special students for shorter periods.

Entrance Examination. Before entering the college, students must have graduated at an approved university, and must pass the following examination:

1. Old Testament: Prescribed books (in English).

2. New Testament: The four gospels in Greek. Questions on subject matter of the Gospels and the Acts.

3. History: "Retrospect of Religious Life in England," by J. J. Tayler.

4. Philosophy: James's "Text Book of Psychology" (Chapters I. and II., and XI. to XXII).

Cicero's "De Officiis" is prescribed instead of the philosophy paper for all graduates who have not taken Latin in the Intermediate or Final examination for their degree.

Under special circumstances the candidature of non-graduates is allowed. These must be over twenty-four years of age.

Both the above entrance examinations are held early in October of each year.

The committee offer exhibitions of £50 for the year to students who reach a high standard in the entrance examinations. It is understood that the exhibitions will be continued for the course of three years.

Every candidate for admission to the college as a regular student for the ministry must send with his application a medical certificate and a recommendation signed by three persons who can testify to his character and abilities, one of whom must be a minister of religion.

To assist students who are unable to bear all the expenses of a university education, exhibitions are offered to undergraduates who fulfil certain conditions. The grants are £75 per annum for undergraduate students in a college of the University of Oxford, £50 for non-collegiate students at Oxford or for students studying elsewhere than at Oxford.

NONCONFORMIST COLLEGES

CONGREGATIONAL. *New College, Hampstead, London*; Western College, Bristol; Yorkshire United Independent College, Bradford; Cheshunt College, Cambridge; *Hackney College, Finchley Road, London*; *Lancashire Independent College, Manchester*; Mansfield College, Oxford; Congregational Institute, Nottingham; Congregational Memorial College, Brecon; Bala-Bangor Independent College; Theological Hall of Congregational Churches in Scotland, Edinburgh.

BAPTIST. Bristol College; Nottingham College; Rawdon College, near Leeds; Regent's Park College, London; Pastors' College, Metropolitan Tabernacle; Manchester College; Cardiff College; Bangor College; Theological College, Glasgow; Dublin College, Ireland.

WESLEYAN METHODIST. Richmond College, Surrey; Headingley College, Leeds; Didsbury College, Manchester; Handsworth College, Birmingham.

PRIMITIVE METHODIST. Hartley College, Manchester.

PRESBYTERIAN. Westminster College, Cambridge.

UNITARIAN. Manchester College, Oxford; Unitarian Home Missionary College, Manchester; *Presbyterian College, Carmarthen.*

SALVATION ARMY. Training Home, Congress Hall, Clapton.

Printed particulars of college curriculum and conditions of entrance may be obtained upon application to the Principal of any of the above.

THE CHURCHES *concluded; followed by* LAW

Continued from page 6496

THE TRADE IN FEATHERS

The Various Uses of Feathers and the Processes Involved in their Preparation. Bed Feathers. Feathers for Millinery Purposes. Quills and Ospreys

By J. P. MILLINGTON

FEATHERS, like hair and nails, are products of the epidermal portion of the skin.

A feather consists of three parts: (1) A *barrel*, or *calamus* which is the hollow, translucent part used for writing; (2) a *shaft*, or *rachis*, which is opaque and filled with pithy substance (this is roughly quadrangular in transverse section with a longitudinal furrow along its inner side—that is, the side turned towards the body; the rachis, together with the calamus, form the quill); and (3) the *barbs*. These are subdivided into *barbules*, and the latter again into *barbicels*. The barbs and their subdivisions constitute the web or *vane*.

Feathers are of different natures according to the parts of the body in which they occur. The contour feathers, or plumes, come chiefly from the wings and tail, and are the most important for ornamental purposes. Besides the plumes there are smaller, softer feathers which are classified into downs, half-downs, and hair-like feathers. Finally, there are the small nesting feathers.

The plumes are the largest of the feathers, and sometimes show magnificent markings and colourings, as in the case of the peacock and pheasant. The downs, on the other hand, are covered by the plumes, and are smaller, more fluffy, and more numerous. In aquatic birds—especially in those inhabiting high latitudes—the fluffy down is highly specialised, and is so elaborate as to form an important feature of the plumage.

Uses of Feathers. The principal uses to which feathers are applied are these:

1. The manufacture of bedding, cushions, etc.
2. Ornamental and decorative purposes.
3. The manufacture of pens, toothpicks, light brushes for dusting and other domestic purposes.

Sometimes not only the feathers, but the whole bird is used as an ornament. This is notably the case with birds of paradise and various tiny humming birds. In other cases some part of the bird—for example, the wing, or the head and neck—is employed, while frequently the long contour feathers are plucked out and used.

The list of birds which serve for ornament is a long one. Among them are:

Birds of Paradise:	Jungle cocks
Black	Kingfishers
Green	Merles
King's	Orange oriels
Bustards	Osprey
Crested pigeons	Ostrich
Grebe	Peacock
Heron	Pheasant:
Humming birds:	Common
Amethyst	Japanese
Emerald breasted	Seagulls
Ruby	Starlings
Indian crows	Terns

There are others, but these are the more common.

Of the feathers usually seen, the best-known are those of the ostrich, while the most valued are those of the egret. The real home of the ostrich is Egypt and the North African States, and these countries still provide a certain quantity. The bulk of the supply, however, comes from South Africa, where the birds were introduced some thirty or forty years ago. The rearing and farming of ostriches has been attended with such marked success that the killing of wild birds has been almost, if not quite, abandoned. The profits from ostrich farming vary from year to year, and are determined by two main factors—namely, supply and demand depending upon the dictates of fashion, and the prevalence of disease to which the birds are particularly liable unless allowed practically unlimited space in which to roam.

The birds are clipped every eight months, and each yields an average of about 20 ounces. The first crop consists of chicken feathers, which are known commercially as *spadonas*.

The ostrich feathers are sold by public auction in London, and for the last five years the quantity sold has averaged about 600,000 pounds per annum. This represents an annual value of £1,200,000 to £1,500,000. About nine-tenths of the total amount comes from South Africa.

The raw material is then distributed for manufacture to various parts of England, France, Germany, Austria, and the United States of America. The main processes of manufacture are known as dyeing and bleaching, laying or preparing, sewing and curling and finishing. In addition to the manufacture just mentioned, there is a large industry connected with the making of boas and feather trimming.

Ospreys. Egret feathers, known to the trade as ospreys, are taken from the long-winged birds of the heron family. In character they are exceedingly soft and silk-like, yet remarkably stiff. The barbs are very fine, long and filiform. These are largely used as ornaments for the hair, generally in conjunction with diamonds. The price is exceedingly high, sometimes reaching as much as £8 per ounce

Considerable feeling has been shown by humanitarians concerning the slaughter of these birds, which are usually killed during the nesting season, as the plumage is then at its best. It is recorded, however, that egrets flourish in confinement, and that the feathers taken from such birds are of just as high a quality, and command the same prices, as those taken from wild birds. It is possible that this industry may be developed so that the reproach of wearing "murderous millinery" may be taken away from those who decorate their hair with these beautiful feathers.

of many different kinds is collected in country districts, and from poulterers in England and the various countries of Europe, and the manufacture of these constitutes a very considerable industry.

Another branch of the feather trade is that of fan-making. In this ostrich feathers are largely employed, though at present these articles are not much in vogue.

Preparation of Feathers. The preparation of feathers consists mainly in the cleaning and dyeing of them. It is usual to dye only those which are intended for ornamental use in boas, trimmings, ladies' hats, etc., but in the case of all feathers a preliminary cleaning operation is necessary, since when taken from the bird they are impregnated with various substances such as blood and natural grease, which, unless removed, would undergo decomposition and give rise to unpleasant consequences. We may consider the treatment according to the three main purposes to which feathers are applied.

Bed Feathers. For the making of feather beds those feathers are used in which the quill is reduced to a minimum and is as pliant as possible. Such are obtained from the domestic fowl, ducks, geese, swans, etc., and the best of them are plucked from the living birds in spring. This kind is preferred to those taken from the body after death, as they are cleaner, freer from blood and animal fats, and less liable to become tainted. They are also rather more springy and elastic, and so better adapted for this particular purpose.

The feathers are first dried in stoves by means of hot air, and then beaten with sticks to render them free and light. The dust is removed by shaking them in sieves, and the feathers are then ready for the manufacturer.

For bed quilts the down of the eider duck (*Somateria mollis*) is unequalled, because in addition to its extreme softness it possesses the property of great lightness. The down is supplied by the female, who, while sitting, lines her nest and continually adds to the warm, soft lining, so that by the time the young are born there is sufficient down to cover them completely during her absence.

Each nest yields about one-sixth of a pound of down, valued at 12s. to 15s. per pound.

Quills. Like the down used in the making of feather beds, the best feathers for quill making are taken from the living bird in spring. The most suitable, and at the same time the most expensive, feathers are obtained from the swan, but large quantities of quills from the albatross, heron, pelican, hawk, owl, etc., are used. For fine work feathers of the crow are employed; but the main source of supply is the goose, which, in certain parts of Europe, is bred almost entirely for this purpose. To all these feathers the following treatment is applied.

The feathers on removal from the body are heated in a bath containing fine sand to an average temperature of 60° C. A portion of the grease and other adhering foreign materials is thereby softened and partly absorbed by the sand, while the remainder is removed by scraping the still warm and pliable feathers. If desired, any pattern or design may be then impressed; on cooling the quill is left as a dry, horny substance, ready for cutting to the shape of pens, toothpicks, etc.

Feathers for Ornamental Use. The feathers intended for millinery purposes are first sorted according to quality and colour, the best colours and the purest whites being retained for use in the natural state after they have been subjected to proper cleaning. Those which are not to be dyed are washed in hot water in which soap has been dissolved. This removes grease and other objectionable matter. After this process they are thoroughly rinsed in warm water, and those that are to be kept white are then bleached. Formerly this was always effected by moistening the feathers and placing them in closed chambers where they were exposed to the fumes of burning sulphur. Now, however, hydrogen peroxide is largely employed as a bleaching agent. It is more convenient to use, and possesses the further advantage of leaving a purer and more permanent white. Feathers and other articles that have been "sulphured" are apt to return to their original yellow tint on long exposure to the atmosphere, or on coming into contact with any alkaline material, such as soap. Bleaching with hydrogen peroxide is not open to this objection.

Even after this treatment some feathers retain their yellowish cast, and to correct this defect they are often dipped into a dilute solution of indigo or some other blue dyestuff. This process is based upon the same principle as the one adopted by the laundress in "bluing" linen after washing, for the added blue neutralises the yellow, leaving a much purer white.

Feathers, the colours of which are unsuitable for natural use, are dyed. Dyestuffs such as logwood and indigo are much used, though a far wider range of colours is afforded by the various so-called aniline dyes, artificial colouring matters derived from coal-tar products.

Before dyeing, the feathers must be well cleaned with soda in order to get rid of every trace of grease, and then carefully rinsed to remove the alkali, which would otherwise affect the ultimate colour.

According to the dyestuff chosen the treatment must be varied, since some—for example, malachite green, auramine, magenta, methyl violet—require a neutral bath, while others must be used in a bath made acid with either sulphuric or acetic acid.

After dyeing the feathers are well washed and then carefully dried in revolving drums.

Curling. After dyeing the feathers usually require a certain amount of curling. This is effected by pulling them over a blunt knife, or by the cautious application of a hot iron. Some plumassiers employ various curling liquors, with which they moisten the feathers before dyeing. These liquors frequently contain small quantities of ammonia, and in some cases substances of a gum-like nature are added, as these help to fix the curl.

FEATHERS *concluded; followed by* SHIRTS AND COLLARS

Continued from page 6425

LARGE GUNS & AMMUNITION

Construction and Manufacture of Large Guns. Making and Charging Cartridges. Shells Percussion and Time Fuses

By JOHN W. WAINWRIGHT

Small Calibre Q.-F. Breech-loading Guns. This type [26] is built up from steel forgings and an inner tube with jacket shrunk on them. The inner or "A" tube forging is first rough turned and drilled, simultaneously from both ends, the tube revolving After this it is tempered and annealed and tested, then opened out to a larger diameter, with a D shaped boring tool working from the muzzle end, and then fine bored with a built up boring tool, with several inserted cutters with burnishers between them They are then lapped out when rapidly revolving by lead laps After this they are finished, turned, and shrunk up Then the rifling operation takes place, the tool used being somewhat similar to that described under Rifle Manufacture

Jacket. The jacket is then tempered and annealed, and then drilled through and second bored and second turned The trunnions are grunched down out of the rough forging, by vertical tools, a number of cutting tools in a bell chuck But in field guns the tendency of later years has been to give all field guns a longer recoil, and to provide them with a large spade at the end of the trail This design has caused radical difference in manufacture of the gun jacket Figure 27 is a Vickers 3 in gun and 28 is an Armstrong Whitworth 3-in. gun The trunnions are done away with on the jacket and a slide or grooved way extends the whole length of the gun Thus, practically, no portion of the outside from breech to the muzzle can now be turned in the lathe, but has to be planed longitudinally, the gun being supported and partially revolved and the tool box arranged to copy the contour of a template fixed upon the machine

The breech is then slotted out in a slotting machine (when of the Hotchkiss or Vickers wedge breech type), the rear face faced and the hole flared out to give easy insertion to the shell cartridge The action holes are drilled through jigs, and a dummy mechanism fitted, to test accuracy, also backsight holes bored. The jacket is then fine bored to a somewhat smaller diameter than the barrel or "A" tube, and this is called a shrinkage allowance In several cases there is a locking ring with bayonet joint which is duly machined.

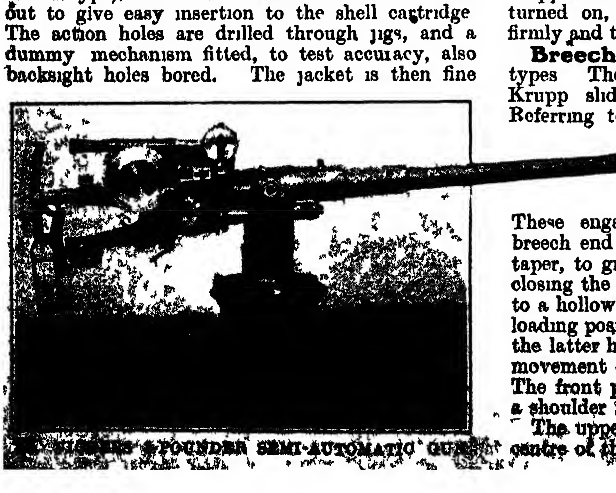
The gun is then ready to be shrunk up. For these small guns a gas fired furnace of simple construction may be used, using forced draught and town gas through standpipes and nozzles This jacket is fixed on a revolving table perfectly upright, and gradually turned round, to get an equal distribution of the heating The jacket is tried over the top of the barrel before heating to ensure it getting into the correct position When the jacket is expanded sufficiently by heat, it is tested by gauges

27 VICKERS 3-IN FIELD GUN

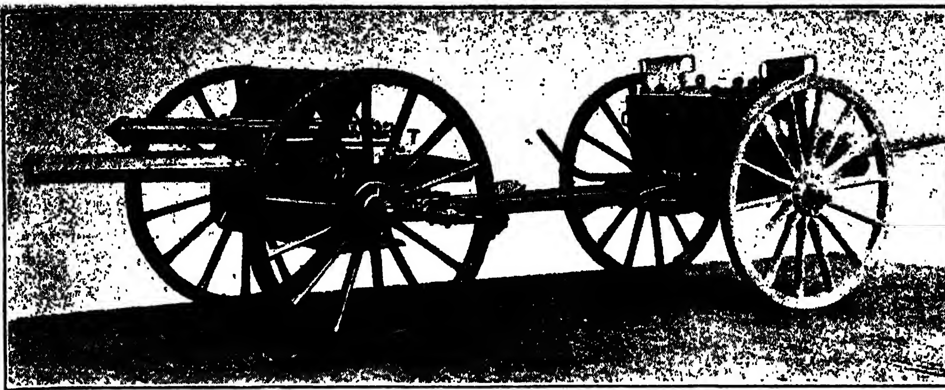
The barrel having been already lowered, and secured on to a plate, into the bottom of a pit alongside, has a taper plug placed in the muzzle to form a lead, and to give protection The jacket is then carefully lowered vertically on to the barrel to avoid making a burr on the locking ring When it is home to the shoulder the locking ring is turned, and the key inserted, the key fitting on the sides only Should there be other reinforcing hoops they are expanded in a like manner and dropped over In each case the water jets are turned on, causing the outside portions to grip firmly and thus to form an integral whole.

Breech Blocks These are of three principal types The vertical wedge, A, the transverse Krupp slide, B, and the screwed breech, C Referring to detail of manufacture of "A," the breech block is of the vertical sliding type and is retained in the breech end of the gun by means of a series of serrated projecting guides, milled in These engage in corresponding grooves in the breech end The block is machined with a slight taper, to give it a slight forward movement when closing the breech The top of the block is milled to a hollow curve to clear the cartridge case in the loading position, and the front is bevelled to press the latter home in closing the breech—the forward movement of the block completing this operation The front portion of the block is stepped to form a shoulder for actuating the extractor.

The upper portion of the block in line with the centre of the gun is bored out to receive the bush



VICKERS 3-POUNDER SEMI-AUTOMATIC GUN



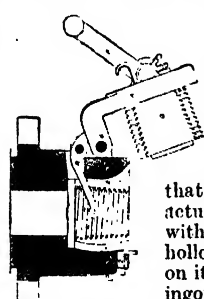
28. ARMSTRONG-WHITWORTH 3-IN. FIELD GUN

for the striker, the former having been previously machined and hardened. This is screwed into the front face to admit the firing pin. At the rear end is provided a sliding cover, a stop pin being provided to limit the opening movement. The striker opening near to the cover is recessed at the top to allow the striker to be removed when the mechanism is assembled. The centre of the lower portion is hollowed out and drilled and end-milled to take the cocking lever, trigger, and mainspring. A wibbled-out slot between this space and the striker opening admits the cocking lever to the latter. Transverse holes are drilled in the lower portion of the block to receive the axis pins for the trigger and cocking lever. The other components, such as the cranks, crank shaft, and sleeve, are machined from steel forgings and hardened.

Semi - automatic and Screwed Breech Blocks. In the semi-automatic type there is also a steel spring of the clock type fixed in a machined-out bronze cover. The extractor, when machined, is pivoted on a hinge pin screwed into the breech of the gun. A cylindrical striker with detachable point and a key is fitted into it. A hole is drilled through the striker for the head of the cocking lever. The cocking lever is forged bell-crank form, and pivoted on an axis pin in the space in the centre of the breech block.

In the Krupp type the breech consists of a transverse slide block with a circular hole through it registering to the chamber when open, but presenting a solid surface when moved across to the closed position.

Referring to the screwed-breech type, there are numerous types of this class. Taking one simple type [29], the screw, which has interruptions (or gaps between), is swung round on a carrier arm, which also has a bevel gear to rotate the screw, so that its threads, which have entered the somewhat radial gaps in the breech screw of the gun, are now threaded, so that they enter and lock into the threads of the gun screw. In this particular type the threads are cut all round and then shaped off to form two interruptions. But a much superior screw breech—namely, the "Welin" type, which has been much improved by Messrs. Vickers—is used for the larger guns.



29. SIMPLE SCREWED BREECH BLOCK

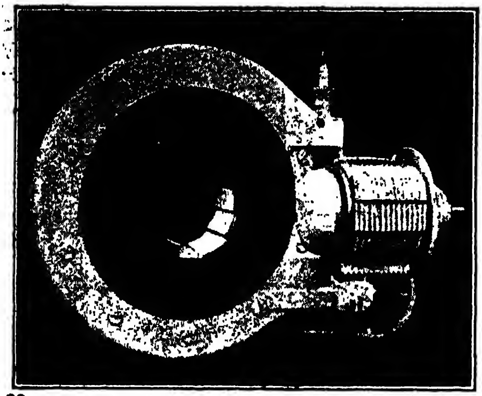
Welin Breech Blocks. This type [31 and 32] gives a much larger thread contact, and therefore support, and for the same reason it is enabled to be shortened, and the gun breech does not need to be radiused for the plug to be swung out. This arrangement of a short plug also enables a very considerable saving in weight to be made in the gun itself at its heaviest portion—namely, the breech end.

The contact area gives as much as 75 per cent. of the circumference as useful support. The thread is of the step-up type. Each segment has a different radius. This would appear to be a very difficult piece of machine work, but the result has been obtained by an ingenious arrangement brought out by Mr. Douglas Vickers. The interruptions, or gaps, are first milled through longitudinally, also narrow tool clearances between the threaded segments. It is then turned, and afterwards screw cut in a lathe, which has an attachment to the cross slide of the saddle, acuated by a cam and strong spring. This enables the tool to snap back quickly to meet the advancing larger radius during the period of passing the clearance groove.

In machining some of the smaller breech plugs, instead of using a forging for each plug, the screw is cut from end to end on a forged bar and then parted off into a number of breech screws, thus saving cost and material. Further, fewer test pieces are required.

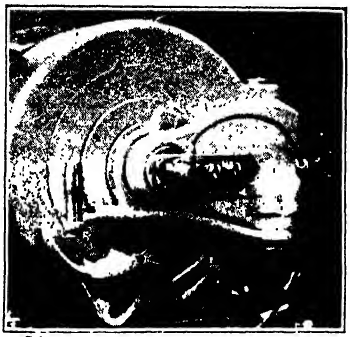
Large Guns. The steel ingots are cast with a large head to ensure soundness. This is cut off in a face-plate lathe by a square, revolving frame, with cutters that are moved forward by transverse screws actuated by a star wheel feed coming in contact with a fixed pin. They are trepanned out by a hollow, annular boring tool with cutting tools on its front face. This, on being fed into the ingot, takes out the centre, thus saving a large cylinder of metal. The ingot is then taken to the large hydraulic forging press and swaged out on a mandrel. Special mechanically-moved turning gear slung from the crane overhead is used. The hollow forgings are then rough bored out from both ends with D-shaped bits, with tooth-shaped cutting edges well supported and backed off to give clearance to the turnings, a copious supply of soapy water under high pressure being carried up to the cutting edges of the tool. They are then rough turned, and taken out to be oil-hardened or toughened and annealed.

The oil-hardening plant is of gigantic dimensions, consisting of high gas-fired furnaces, with firebrick



30. VICKERS 12-IN. BREECH MECHANISM (OPEN)

linings and with hinged front-door opening outwards all the way up, and a table at the base revolved from below by worm gear. Above this, and spanning over the furnaces and oil-tanks, is a 100-ton goliath crane worked by hydraulic power. The oil-tanks are large enough for 16-in. guns, and contain some 15,000 gallons of rape oil. They are partially sunk in the ground, and water is circulated round the annular chamber surrounding the inside shell of the tank, to keep the oil at a fairly equal temperature, and to prevent its firing. The tube is heated to about 1,500° F., and soaked at this heat for some time. Further, to ensure equable heating, it is revolved on the table before mentioned. The top doors are then opened, and the clips put on the tube, which is then lifted by the overhead crane, and plunged into the oil-tank. When ready, it is then taken out and replaced in the re-heating furnace for some time and maintained at a temperature of 700°F. to anneal it. Afterwards it is slowly cooled, and a further tensile test is taken. If correct, it is then taken to the boring lathe and second and fine-bored, and also lapped out. The various jackets and hoops are treated in a similar manner, an allowance being made for shrinkage.



31. 6-IN. BREECH MECHANISM (CLOSED)

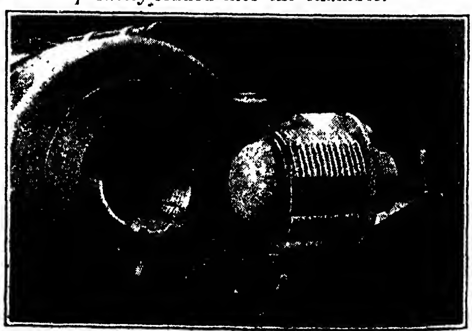
Wire-winding. As the larger guns are wire-wound, they differ somewhat in construction. There is an inner tube, which is second-bored inside, but finished turned outside, and over this is placed the "A" tube proper, and on to this is wound, in the case of the 12-in. gun, some hundred miles of steel ribbon wire under great tension. This winding on tension is regulated by grippers, held towards each other by weighted levers. The weights of these are adjustable in order that the tension may be increased or diminished, as required by theoretical construction. The gun revolves, winding on the ribbon in advancing steps or layers. The reel and apparatus traverse the bed longitudinally by a long feed-screw worked by hand. The wire is driven home by a workman with a copper drift, who also carefully examines the wire in transit and *in situ* to detect any defect.

When completely wound, should there be any rough edges on the wire or on the clamp rings, they are trued up in the lathe by spring cutting tools, or, in other cases, ground by emery wheels. Then the jacket and chase hoops which have previously been fine-bored, with a small shrinkage allowance to suit, and also finished turned, are dropped over, and shrunk on. The somewhat contracted bore is finished inside by lapping out. It is also chambered by a built-up broaching-out tool, or, in some cases, bobbed out by an emery wheel on a former. It is now inspected and measured up carefully in the bore, a micrometer gauge being used which registers the dimensions on a dial outside the muzzle end. It is then rifled in a tangent bar rifling machine somewhat similar to that described in our consideration of rifles.

In the meantime, the breech bush has been machined. To make this, an ingot is trepanned and hollow forged under the press in a length suitable for making twenty bushes. It is then rough-turned and bored, and hardened in a similar manner to a gun tube. It is now parted off into lengths and a thread is cut on the outside, and, further, the interior has the interruptions and stepped segments cut into it by special machinery.

When the gun has been rifled and lapped out, the breech bush is screwed in and fixed. The gun is again inspected minutely; to do this in the interior, electric lamps and mirrors are used to detect any defect. Also, internal impressions are taken by wedging inside plastic gutta-percha, which clearly reproduces any roughness or irregularity, and can be examined at leisure when withdrawn.

Obturator. In the case of large calibre guns, no metallic cartridge cases are used, but the efflux of the gases is prevented by the obturating pad. This consists of a plastic pad of asbestos with an unguent kneaded thoroughly into it. This mixture is formed into a pad between dies, under intense pressure, and covered with canvas. When in the gun, the pad is contained between front and rear metallic discs, but is free to expand at the circumference. On firing, the pressure forces back the front mushroom plunger. This compresses the pad longitudinally, and forces it outwards against the chamber, to make a gas-tight joint. The plunger has a hole drilled through its centre, in order that the flash from the primer may communicate with the charge. This charge lies in rear of the shot, each having been separately loaded into the chamber.



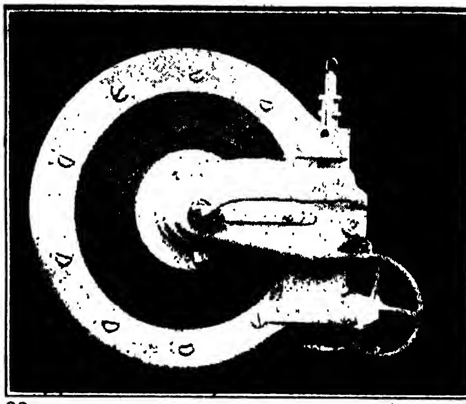
32. 6-IN. BREECH MECHANISM (OPEN)

The breech mechanism is now mounted [30 and 33]. The mechanism is arranged so that, by turning the hand wheel, the breech plug is first rotated and unlocked, then drawn out longitudinally. The obturating pad being now clear, the whole is swung out from the breech of the gun. These motions are obtained by means of a pinion and actuating lever, which rotate the breech plug with gradually increasing rapidity, unlocking it. By a combination of the sliding bar and roller stud, a sleeve is turned, causing the plug to have a longitudinal rear motion. On this movement being continued, the actuating arm swings out the mechanism clear of the gun.

Proof of Guns. After the final inspection of the guns as regards machining, they have to be tested by proof charges at a suitable range. The range, if required for large size of guns, must be in an isolated position near the sea, and should have a railway siding right on to the mounting ground, so that the largest ordnance can be conveyed there. To try the guns they are mounted on heavy, cast-iron surface plates, anchored down to a massive concrete bed. Usually an overhead gantry crane of 50 tons capacity spans the railway siding, so that the heaviest ordnance can be mounted with facility. The targets for armour plate trials are usually erected some distance away against a huge bank of sand, while fixed targets are erected on piles some thousand yards to seaward, and floating targets can be moored at any practical range. The buildings include the magazines for explosives and a handling house, chronograph house, workshops, a splinter-proof shelter, look-out shelter, etc.

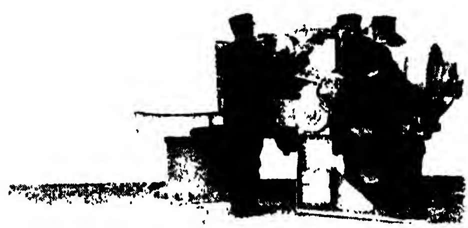
As the proof charges give pressures much in excess of those of the service charges, it is necessary to obtain information on this matter. To do this a crusher gauge is used for the direct measurement of pressure. The powder gases act on the base of a piston exposed to them, transmitting this, and compressing cylinder of copper. The amount of this compression is an index of the maximum pressure acting upon the piston base. Several crusher gauges are used to obtain an average. The copper cyinders have had given to them an initial compression, which is recorded; also, from the same rod from which they have been taken, others are compressed to an amount greater than that likely to be obtained by the maximum pressure in the gun, and each increment of load is recorded with the equivalent compression. Therefore it is necessary only to measure the length of the cylinders, as compressed in the gun, and refer them to the table obtained by the hydraulic pressures above referred to.

Chronograph. To measure the velocity of the shot an instrument called the *chronograph* is used. This is a time measurer, and is used to record the time taken by a shot traversing from



33. VICKERS 12-IN. BREECH MECHANISM (CLOSED)

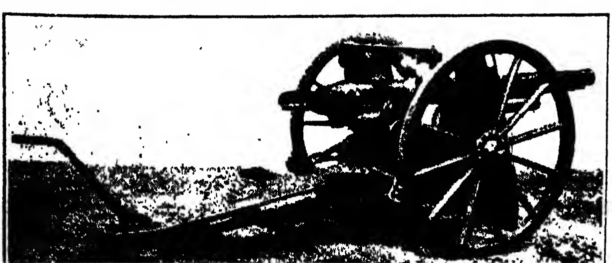
the muzzle of the gun to a point some distance ahead. Two electromagnets are supported vertically. When the circuits are complete they are magnetised and each one sustains a brass rod. One rod is called the *chronometer* and is a long one, the other is shorter and is called the *register*. On the register falling, it causes a knife-blade to indent the falling chronometer rod. Forming part of the circuit to the magnet holding up the chronometer rod is a fine copper stretched across the muzzle of the gun, while a certain distance ahead,



34. 6-IN. QUICK-FIRING GUN ON PEDESTAL MOUNTING

directly in the path of the shot, there is placed a screen of fine copper wires laced across, and insulated from the screen. This wire forms part of the register circuit. Further, a switch is arranged that can break both circuits simultaneously, called the *disjunctor*. When this is thrown over, both rods are released at the same time, and a mark is indented on the chronometer rod. On firing, the shot breaks the first circuit, causing the chronometer rods to fall, and the shot in passing through the screen breaks the second circuit, causing the register rod to fall. The mark now made is measured to that made by the disjunctor simultaneous release, and the average velocity is obtained therefrom.

The above is an improvement on the Boulengé type by Colonel Holden, R.A.



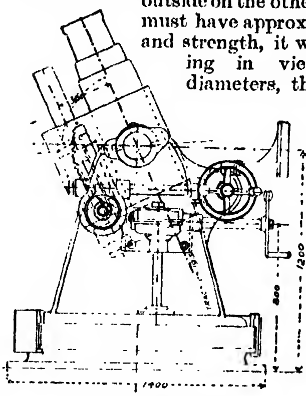
35. VICKERS 75-MM. FIELD GUN AND CARRIAGE

Field Carriage. The trunnion and axle bearings of a field carriage [35] are in one forging, and are riveted on to the trail by ample flanges. The traversing plate which supports the cradle is a steel casting. It has two trunnions which stand out horizontally upon it. These are turned on the journal part on the collar. By means

of these trunnions the gun is elevated or depressed. The trunnions lie in bearings in the trail and are kept in place by cap-squares. The boring bar is passed through the bearings to true them up with the trail. The recesses are slotted out, and the cap-squares fit in sideways. A socket is formed in the traversing plate, in which the traversing pivot rests, and around which the gun is traversed. This traversing pivot is provided with horizontal bearings (for the ranging drums) round which the gun and cradle can be elevated.

The traversing plate extends to the rear in two arms with a cross member to form a bearing for the traversing segment. The latter is machined to radius, and carries the ranging gear. The elevating gear is telescopic, and is arranged for independent, or for simultaneous elevation of the gun and sight. The separate and independent elevation are placed one on the left and one on the right side of the carriage. The one on the left elevates the whole system of the gun, cradle and sights, and is used for pointing. The gear on the right-hand side is for ranging the gun and does not influence the sight. An indicator shows the range of the gun corresponding to the elevating with degrees with line of sight. The machining of this work with internal and external threads is done on a screw-cutting lathe. All the gears are cut to conform to theoretical lines, as lost motion must be avoided. A hand wheel is on the right-hand side with a spindle and worm upon it. This gears into a segment of a worm-wheel, to give some degree of traverse in either direction.

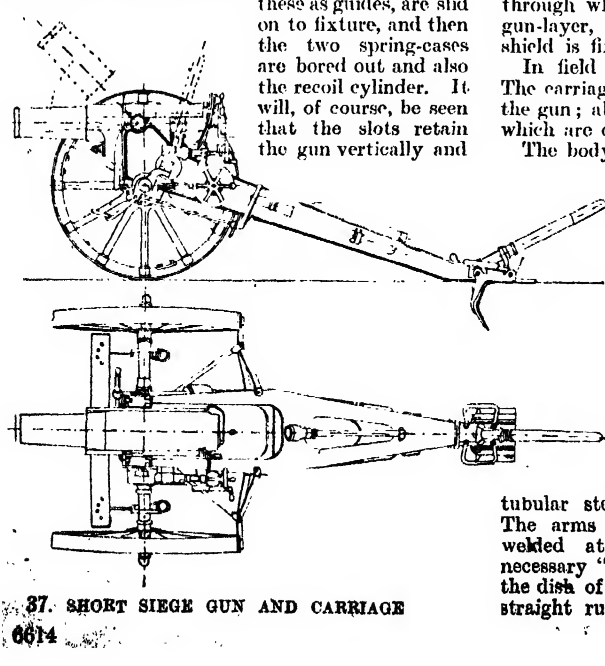
Cradle and Cylinders. These are made of manganese bronze and contain the recoil arrangement and running-out springs. A lug is formed on the under side. These are difficult castings to make, owing to the thin walls and long slides causing contraction difficulties, but this has been skilfully overcome by careful moulding. As in other castings, the runners and fins have to be removed, also the cores. They are then sent to the machine shop. The long grooves on each side are planed out on a special machine, and using these as guides, are slid on to fixture, and then the two spring-cases are bored out and also the recoil cylinder. It will, of course, be seen that the slots retain the gun vertically and laterally. In the recoil cylinder, a liner is forced in with an orifice which controls the flow of the liquid past the piston, through a gradually closing port. The spring-cases that are on each side of the recoil cylinder each contain two springs, enclosed one within the other, but separated by a tubular casing having a rim on the inside at one end, and at outside on the other. As these springs must have approximately equal range and strength, it will be obvious, having in view the different diameters, that the section and pitch of the coils must be carefully calculated to obtain a satisfactory result. The inner spring bears against the enlarged end of a rod which, after passing through the spring, is securely attached to the lug under the gun, and at the other end it pulls on the inside rim of the tubular case, enclosing this spring, while the outer spring bears against the outside rim of the tubular case: its rear end presses against the cradle itself. By this telescopic arrangement the compression of each spring is about half the distance travelled by the gun in recoiling. A large initial compression has to be given to these springs by screwing up. Suitable wheel brakes are attached. The bullet-proof shield is bent in such a manner that a horizontal portion forms the seat, the rear vertical portion of the back, while the front is continued down below the axle, thus screening the men well, and at the same time forming a seat when limbered up for travelling. The shield is flanged all round the outside edges and reinforced by right angles round the opening through which the gun projects. To protect the gun-layer, in these long recoil guns, a protecting shield is fixed at the rear end of the cradle.



36. HOWITZER

In field equipment there are three limbers. The carriage-limber, as shown in 28, travels with the gun; also the carriage and ammunition limber, which are coupled up and travel together.

The body is made of bullet-proof steel and contains a number of pigeon-holes, into which are inserted and tightly fitted baskets to contain the made-up rounds. These baskets have a wicker cover with a strap fastening. The end door has to fit up very tightly against these covers, and is padded with felt and leather. In the under-frame, corrugated and flanged plates are used which at once give strength and lightness. The limber hook is made of a steel forging, into which is welded a wearing-strip of special high-grade steel. The pole is made of straight-grained ash, well seasoned and free from defects. The axles are tubular steel with collars formed upon them. The arms are swaged down, turned in, and welded at the ends. These arms have the necessary "hollow" and "lead," the one to suit the dish of the wheels, and the other to ensure straight running on the conical arm. The arms



37. SHORT SIEGE GUN AND CARRIAGE

are slotted through to receive a lynch-pin, which retains the wheel in place.

Wheels. The spokes are of cleft oak, well seasoned and selected. They are turned in a copying lathe, and the nave ends are carefully tapered. The spokes are shouldered down to a round section where they fit into the felloes. The felloes are in some cases sawn out of ash with the grain running round the circumference. They are bored for the end of the spokes to fit into and are dowelled together at the joints. In other cases of recent practice, they are made of bent ash. The ash, having been steamed, is bent while hot by screwing on to moulds, and left for some time until it retains the required shape. These are bent in longer lengths in the old system.

The wheel-boss flanges are sometimes cast in bronze, or malleable iron, or of pressed steel, with projecting mid-feathers into which the nave of the spoke is inserted. Outside and socketing on to the boss-washer is the outside disc-washer, which is bolted up to it. Before insertion, the nave ends of the spokes are well-coated with white lead paint. The felloes are driven on to the spokes, and the spoke ends wedged. Then the welded tyre is placed over this, and in modern practice the shrinking on is done by means of a series of hydraulic rams all round the circumference and acting radially inward simultaneously. Inside the socket of the boss-washer a pipe-box, previously bored out and with oil grooves cut in it, is inserted to form a bearing. Some of the European nations use forged iron or steel wheels.

Siege Guns and Howitzers. The tendency since the Boer and Japanese wars is to use a siege gun [37] with high velocity, and consequently longer gun, for field service; therefore the weight has to be kept down.

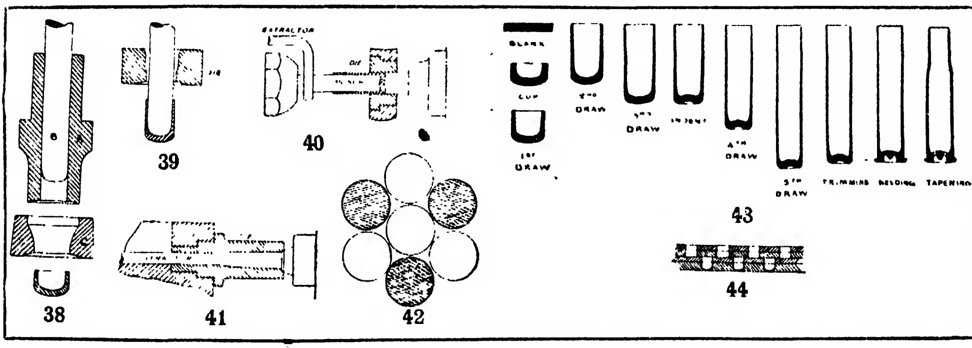
For plunging fire, howitzers [36], with high angle fire are used for field, siege, and garrison purposes.

Mountings. These features cover a multitude of designs—for instance, naval mountings, field carriages and limbers, howitzers, fortress artillery and barbette mountings. It is impossible to go fully into the manufacture of all these, so the 6-in. pedestal mounting [34] is given in detail, and the others are lightly touched upon. This mounting consists of the following principal parts—namely, pedestal, pivot and carriage, cradle, and shield.

The Pedestal. The pedestal is of forged steel, being flanged at the bottom, and is secured to the deck of the ship with bolts. It is bored and bushed to receive the pivot stem of the carriage, and has at its base a horizontal ball bearing on which the whole training mass revolves. The top of the pedestal is bored out to receive the training worm wheel, the lower part of which forms a bush, this latter fitting closely to the pivot stem of the carriage. The upper part of the wheel has teeth cut in it for the training worm to gear into, and is provided with a circular facing for resting on the top of the pedestal. The clamping gear is fitted for controlling the mounting, and consists of a friction block, set screw, two Belleville washers, clamping screw, clamping handle, and two stop studs. The ball race consists of a steel block fitted to slide in and out of the pedestal from the rear.

Pivot and Carriage. The carriage is a steel forging of two side cheeks and a bottom, with the pivot projecting down. The pivot is a solid steel forging. It is faced on four sides in the planer, then two holes are drilled through it, and the metal of the centre portion is taken out by saws, meeting the drill clearance holes. It is then finished slotted inside. Recesses are formed on the inside on the cheeks for the reception of trunnion blocks, and are constructed so that the gun may be drawn inboard after the blocks are unlocked, without any lifting. The trunnion blocks are forged steel, and provided with locking blocks operated by links and rocking lever on the toggle joint principle. Suitable handles are provided for operating the links and locking blocks, so that the latter may be moved in order to engage with the recesses in the carriage when locked. One block moves upwards, and one downwards into oval recesses in the cheeks in the pivot. On each side of the carriage is bolted a steel side-bar, the left-hand one carrying the elevating and training gear and platform, the right-hand one carrying the training gear and platform. Steel stays are provided, one on each side of the carriage to support the shield.

Cradle. The cradle is made of steel plate, and is shaped to take the gun. It also carries the recoil cylinder, spring cases, sighting gear, guard plates, reserve oil-tank, and cover plates. Bronze bearing strips running circumferentially, are provided at front and rear end of the cradle, on which the gun slides: and at the trunnion end a cap of forged steel, also having manganese bronze bearing strips, is bolted to the cradle. Two key ways, running longitudinally, and bushes with bronze are provided, one in the cap and one in the bottom of the cradle, forming guides for the keys on the gun. The trunnions are of steel, screwed and secured into the cradle.

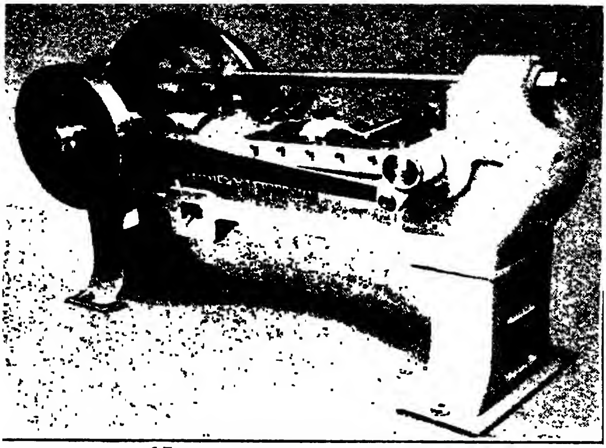


MANUFACTURE OF CARTRIDGES

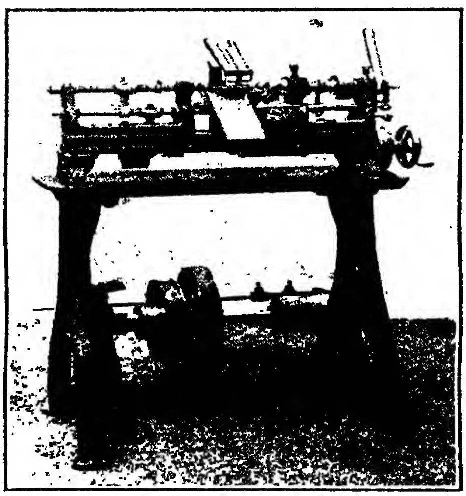
38. Blanking and cupping punch and dies 39. Stripping the case 40. Indenting tools 41. Necking or tapering
42. Plan of punch and strip 43. Various stages of drawing from blank to fin 44. Fulminate plates

The compressor bolt is secured to a steel crosshead, which is fixed to the lug on the breech end of the gun. In addition to the spring-case being supported at the ends of the crosshead, steel supporting straps are provided, binding cases to the cradle and recoil cylinder.

Sighting Gear. The sights are fitted one on each side of the mounting, and are arranged to be actuated by a separate sight setter on the left side. A special feature of the sight are the dials with spiral grooves: these give large and clear readings for range and deflection on the circumferences. The grooves are formed in a milling machine with vertical spindle, free to revolve and with downward feed, but with a fixed vertical axis, the dial being placed horizontally on a revolving table with a cross-traverse. Thus, as the dials revolve, the cross-feed motion continually decreases, the relative distance between the centre transversely of the dial and that of the vertical milling cutter, thus forming a spiral groove of equal pitch. Backlash, due to the wear of the working parts, is eliminated by the use of divided spur gear, one-half of which can be advanced to compensate the wear. A variable power, day and night sight telescope, is provided on each side, and, in addition, open sights are fitted when required. The rocking bar and carrier arms are machined out to channel section, and gauged. Mandrels representing the telescopes are accurately placed, and bedded into the clip brackets. To test the gear for accuracy, it is fastened alongside the true surface table, and the relative heights are tried by scribing blocks with a clock face micrometer containing multiplying gear which enables it to give large, clear readings for minute measurements.



45. INDENTING MACHINE



Ammunition. The manufacture of metallic ammunition, or cartridges, involving as it does severe punishment to the metal cases in their production, by successive pressings, drawings, and squeezings, together with a number of annealings, necessitates the use of a most ductile metal, which experience has shown to be an alloy consisting of 70 per cent. of copper and 30 per cent. of zinc. The metal, which is melted and cast into strips, is by successive rollings reduced to the required thickness, and cut into strips of a suitable width.

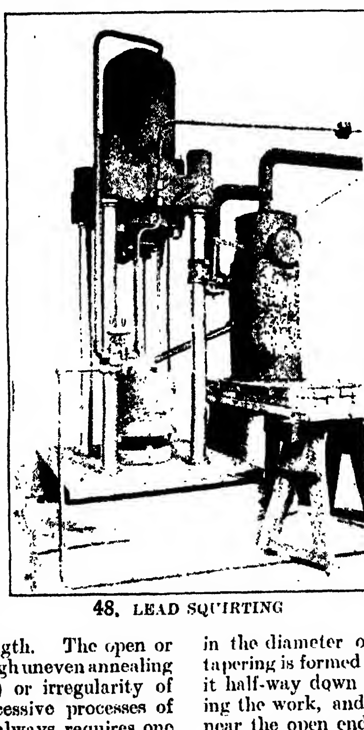
In the production of small cartridge cases, the first operation consists of cutting-out the blank and cupping it in a die press. The strip of metal is automatically fed into the press by a pair of rolls, which receive an intermittent motion from a ratchet wheel and pawl. When the metal is at rest over the

die the outer or hollow punch [A in 38] descends, cutting out the blank or disc. When this punch reaches the bottom of its stroke, the inner punch, B, then descends, pushing the disc through the die C, and thereby forming it into a cup.

Making Cartridge Cases. To use the strip of metal in the most economical manner, and avoid an excess of scrap metal, three blanks and cups (or any greater odd number) are made at each stroke of the press, the position in plan of the punches being indicated by the dark circles in 42, the metal being fed forward a distance slightly in excess of the blank diameter after each stroke. By the three succeeding operations the cup is drawn or extended, each one reducing its diameter and the thickness of the sides or walls, and at the same time increasing the length. In the machine for this purpose the cups are fed or placed by hand into recesses in a horizontal intermittently revolving table, each in its turn coming over a die, upon which it rests. The punch, then descending therein, carries it through the die, squeezing its sides, which reduces the diameter, and at the same time extending the length. On the return stroke, the case, which at the open end expands somewhat, is stripped or pulled off the punch by the die which it previously passed through [39]. The wall of the case or shell is required to be taper, or otherwise it is necessary for the metal of the shell to be thicker at the closed end and thinner at the open end. To attain this, the drawing punches are made taper, being smaller in diameter at the end entering the shell.

47. HAND CAP-PRESSING MACHINE

Indenting and Extending. The thickness of the metal in the end of the case has not been materially reduced, and it is now necessary (before proceeding with the drawing or extending operations) to indent the end of the case. This at the same time acts also as a preliminary heading operation, or forms the end so that an excess of metal is left therein, which will be required later. A machine for this purpose is illustrated in 45. The cases are placed into an incline shoot by the attendant, and are automatically taken therefrom upon a punch or mandrel when it is coming forward, which, when at rest in the forward position, receives a blow or squeeze from a die which is held in a toggle-slide, thus forming the indent. Upon the return stroke of the punch the case extracts itself and falls into a receiving box below. The tools for indenting are shown operating in 40.



48. LEAD SQUIRTING

Following the indenting there are two further operations of drawing or extending to obtain a case of the required length. The open or thin end of the case or shell, through uneven annealing (which will be described later) or irregularity of the metal caused by the successive processes of drawing, becomes ragged and always requires one or more trimming operations, an excess of metal being allowed in the blank for this purpose.

A machine for this process is illustrated in 46. The cases are placed in an incline shoot, and are automatically taken therefrom upon a revolving —and reciprocating—mandrel, a revolving cutter coming into contact with the case when the mandrel has carried it forward a set distance, trimming or cutting off the surplus metal at the end, thereby leaving the case its correct length and with a clear end. Upon the return stroke of the mandrel, the case is extracted therefrom, falling into a suitable receiver.

"Heading" and "Necking" Cartridges. The next operation consists of pressing or forming the head on the case, otherwise known as "heading." In working the heading machine the cases are fed by an attendant into a shoot, from which they are automatically taken upon a punch when making its forward stroke. As the punch with the case upon it comes to rest in the forward position, the toggle-jointed slide containing the die comes towards it from the opposite direction, giving it a powerful squeeze and forcing the metal to flow into the required form. Upon the return stroke of the punch, and the release of the die, the case is self-extracting and falls into a box. The form of the end of the case before and after the "heading" operation are shown in section in 43, which also shows the various stages from the blank to the finished case. It is sometimes necessary to have a final indenting operation after the heading so that the anvil contained in the head and upon which the cap is struck when firing may be properly raised, and the chamber for the reception of the cap properly formed.

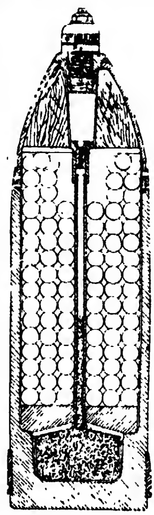
Tapering or reducing, commonly known as "necking," consists of closing in the open end of the case to a smaller diameter than the main portion of the body. In the machine for this process the cases are fed down an incline shoot in the usual manner, the one to be operated upon falling into a recess at the bottom, and being taken therefrom by a pair of fingers projecting from a rocking shaft actuated by a cam, placing it in the direct line of punch, which upon the forward stroke extracts the case from the fingers, and at the same time forces the open end into a taper fixed die. A mandrel which enters the die from the opposite end following up the punch on its return stroke, positively extracting the tapered case from the die, allows it to fall into a receiver. The tools are shown in action in 41.

In some instances, where there is considerable reduction in the diameter of the open end of the case, the tapering is formed in two operations, the first taking it half-way down the die, and the second completing the work, and forming the short sharp curve near the open end.

Piercing and Annealing Cartridges. Piercing consists of forming two small holes in

the head of the case, for the fire or flash from the cap. This operation is sometimes performed in a horizontal, automatic drilling machine, but more frequently in a special machine. The cases are fed by hand into holes in the intermittently revolving table, and are carried under the piercing tool fixed in the top of the frame, which descends and pierces the holes. An ejector worked from the crosshead below extracts the case after piercing. Sometimes the piercing is performed by two independent punches working from opposite sides of the case. The mouth or open end of the case now requires rimering out a little, so that the bullet may readily enter. Not the least important part of the production of the cases is the numerous gauging tests which are necessary to assure accuracy.

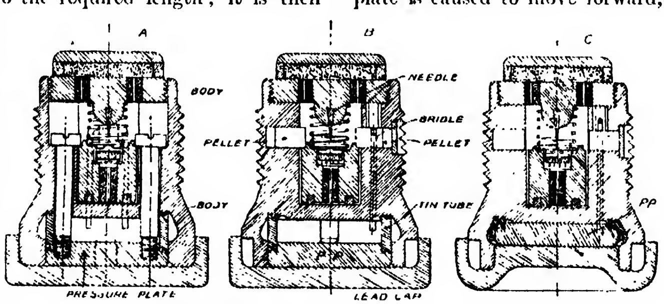
Annealing may be defined as the release of strain in the metal which has been produced by mechanical treatment. The effect on the metal cases set up by the various drawing, heading and tapering processes causes it to become brittle; for this reason there is a limit in the amount of work in reducing or altering the form of the area of the metal it is possible to perform at each operation. These defects of homogeneousness of structure may, however, be removed by heat treatment. The cases are heated with care, and then allowed to cool gradually. The operation of annealing may be performed either in a revolving gas-blast furnace, or in larger quantities by a coal-fired furnace, the temperature of which should be between 550° and 650°.



49. SHRAPNEL SHELL

When the cases have been annealed there is a layer of oxide on their surface, due to being heated in contact with air. This oxide is removed by dipping in acid liquids and finally by swilling in water. The corrosion may also be due to sulphur and other foreign bodies derived from the fuel. If strong and hot aqua fortis be used, the metal is liable to be dissolved and present a rough surface; for this reason a weak solution should be employed for cartridge cases.

Bullet-making. The next process consists of the bullet-making proper, the lead rod, which has been formed in a lead-squirting press [48], being automatically fed into a special machine. The rod is first sheared to the required length; it is then taken by a punch, and forced into a die which is the correct shape and form of the bullet, the finished bullet being finally extracted automatically from the die. The envelope for covering the bullet—the metal for which is an alloy of copper and nickel, better known as *cupro-nickel*—is made in a similar manner to the cartridge case—that is, the blanks are cut out and the cups formed at one operation. They then require extending, being drawn four times in succession; this leaving a rough edge at the end, a trimming process is necessary to complete the envelope. The lead cores are now placed in the envelopes and taken to the coring machine, being placed in a shoot, from which they are automatically taken between a punch and die and the lead core being forced tightly into its envelope, the whole being self extracting, and a completely encased bullet is delivered from the machine. In some instances two or more operations are required, the form of the conical end being thereby somewhat reduced.



Before firing During flight

50. 4·72-IN. BASE PERCUSSION FUSE

The cap is made of copper, and it is necessary that the metal employed be as nearly pure as possible, and perfectly soft, so that it may be formed to the necessary shape without fracture. The metal strip generally used is from ·010 to ·014 of an inch in thickness, and is cut out and formed at one operation, in a similar manner to that adopted in producing the caps for cases. In some instances the caps are trimmed or faced, this operation being performed automatically in a special cap-trimming machine. After this they are polished in a shaking or tumbling machine.

Charging Caps. They are now ready for charging, the composition employed for this purpose being fulminate of mercury, combined with other ingredients in order to ensure the ignition of the powder charge by the blow struck upon the cap. The fulminate is highly dangerous to handle, though comparatively free from danger in charging when the work is performed in a suitable machine. The caps are placed by hand into a copper plate which is provided with a number of holes of a suitable size. The plate is then put into the lower part of the charging machine, and has three brass plates above it. These plates are accurately ground together and work with little friction. The plates are all perforated with holes corresponding in size to those in the caps [44]. The perforations in the lower plate are exactly opposite those in the caps, while those in the upper one are half-way between or over the blank portion of the lower plate. The middle plate—which is a sliding one—has its blank portion below the holes of the upper one while the latter is being charged. When the holes of the upper plate are filled with the composition, the middle plate is caused to move forward, so that its holes come under those of the upper one, taking therefrom the composition. Thus, when the holes of the lower plate communicate with those of the middle one, the caps are filled with a quantity of composition corresponding to the thickness of the centre plate. It is now necessary to press the composition in the charged caps. For this purpose they are taken to a pressing machine. A small machine for hand use is illustrated in 47. A larger power-driven machine is, however, more frequently used, and consists of a frame having a crosshead working vertically through

the intervention of belts, gearing, and a crank shaft, and also having a table which is recessed to hold the plates containing the caps; each plate contains 1,000 caps arranged in rows of 25. The table has an automatic intermittent feed, arranged so that each row of caps is brought in its turn directly under the plungers contained in the crosshead, which then descends and presses the fulminate tightly into the cap. The row of caps, being compressed, rests upon a number of movable bases which are kept up to their work by counter or balance weights, so that the pressure on each cap is regulated by—and cannot exceed—that exerted by the balance weight, which can be varied to suit conditions and may be as much as 1,000 lb. on each cap.

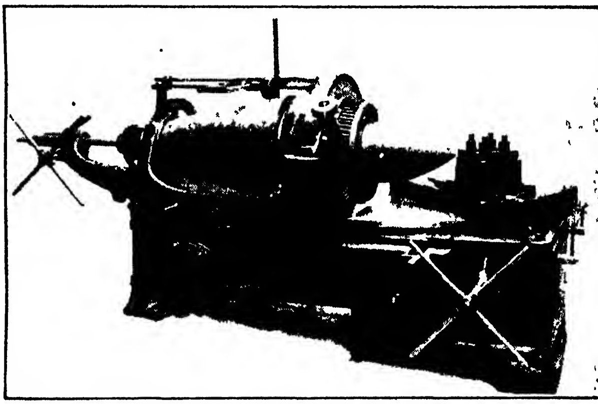
The surfaces of the compressed fulminate—the caps still being in the receiver plate—are now covered with a small piece of tinfoil, and then varnished, the apparatus for varnishing having a plate which is covered with a solution of spirit and shellac. A number of small vertical plungers are caused by the operator to descend on the plate, each taking up a thin layer of the varnish; the plunger plate is then raised, and the varnish plate removed, the receiver containing the caps being substituted; the plungers are again brought down, and leave a thin coat of varnish on the surface of the compressed composition or fulminate. The cardboard or felt wads are made in a cutting-out press, the sheets of material being self-feeding, and the blanks are cut therefrom by a punch and die.

Assembling Cartridges. The various parts are now ready for assembling. The caps are embedded into their cases by a machine. These cases are placed in the long incline shoot, and the caps in the short one, a cap and case coming together at each stroke of the machine, the cap being tightly forced in. Upon the release of the pressure, they fall into the box below. In loading the case with cordite, about sixty pieces of which—somewhat resembling fine twine—are required to fill each case, the pieces are automatically cut to length, filled into the case, and pressed home. The cartridge is now ready to receive its wad and bullet, and the final operation of securing the bullet.

The complete cartridge is then cleaned and passes through the inspection stage of gauging and rectifying, and is finally weighed in an automatic machine having three receivers, one each for those of correct weight, one for lighter and one for heavier, the limit of variation being about two grains.

Shrapnel Shell. This is principally used for field and naval purposes, and one type is shown in **49**. It consists of a hollow steel case, with a solid base, filled with lead bullets. In the case of the 6-in. there are over 500 bullets. On the inside, near the base, is a shoulder for a steel diaphragm to rest upon; below this is the bursting charge, which is in communication with the fuse and head of the tube. The contact head is of brass, and contains the time fuse at its nose. This type of shell is fired out of the gun, the fuse having previously been set, and when in the air over the object—such as infantry, cavalry, or boat flotillas—the flash from the ignited fuse passes down from the fuse to the bursting charge. The bullets, etc., then fly forward with accelerated speed. The hollow forging is bored out to the larger diameter for the bullets, and the diaphragm; and to the decreased size for the powder chamber. Then the open mouth towards the head is enlarged, and into this the finished brass head is inserted, and riveted with brass rivets. Inside the head is a wood filling plug, and at the point the time fuse is screwed in. The body is turned in the ordinary way, and the driving band compressed into the recess. The lead bullets are machine moulded, and then pressed into charcoal to fill the case.

Small Shells. Small shells—armour-piercing 6 pounder steel—are in some cases forged under the steam hammer from a round bar; in other cases they are hollow forged and the base turned over in presses. They are then annealed and bored out. The interior inside the point is bored to a special shape, and is formed by a copying arrangement at the back of the shell. They are then rough turned on the parallel part and then the ogival, or conical head, is turned in a special lathe [**51**], which radiuses round the body. The shell is then reversed in the chuck and finished turned, and the groove for recess cut in to contain a driving band. There are several projections left standing up in this recess, and these are machined in the form of waves by the action of a cam acting upon the slide rest. These projections



51. SHELL-NOSE TURNING MACHINE

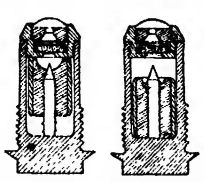
eat into the copper driving band, and the wavy contour prevents the band slipping round. The screw threads are cut into the base by a special tool.

The shells are hardened in water from the point for some distance up. The plugs are made from the bar in a hollow mandrel lathe, and are screwed tightly home into the base of the shell. The copper driving bands are compressed into the recess by a press having a relief valve, and the outsides are tapered to the front, and annular grooves are cut in them. The driving band takes the lands—or projections—and grooves of the rifling, so that the shell revolves when passing out of the gun; at the same time it obturates or makes a gas-tight joint, so that none of the powder gasses pass beyond this band. The nose is now bobbed up to the required shape by high speed emery wheels, controlled by a former saddle to give the cone shape and sharp point. They are now lacquered, inspected, and painted.

Armour-piercing Shell. This class of shell is a steel-tempered forging, with ogival-pointed head, with a small-size chamber inside for high explosive charge, and generally is fitted with a base fuse. Also many projectiles are fitted with a

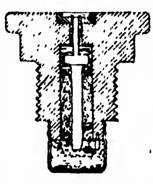
soft steel cap, which protects the front and generally eases the penetration of the shell by preventing its being broken up. The operations are somewhat similar to the smaller shell.

The shell is bored and counter-bored—or enlarged—inside, and the smaller diameter at the base has threads cut in it by internal milling, or by fixed cutters, to which the correct feed is given. This shell and others, after internally heating by steam, are coated with lacquer, to give a smooth internal surface to prevent premature explosions. The shell is then painted, and distinctive bands, showing the nature of the shell, are lined upon them. A semi-armour-piercing shell has thin walls, but is strong enough to withstand the shock of discharge. On striking or penetrating an object, the base percussion fuse ignites the burster and breaks the shell into fragments.

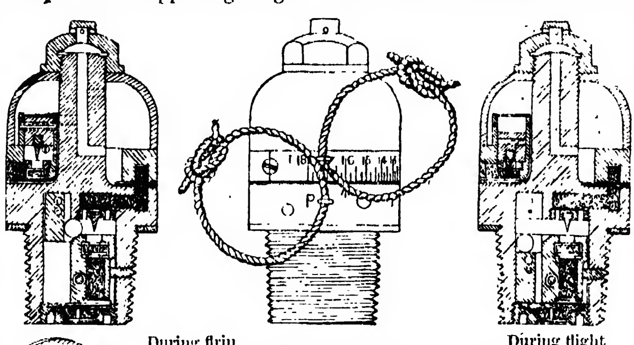


52, SMALL FUSES

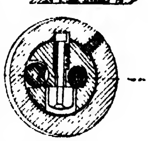
Large cast steel common shell, suitable for 12-in. to 5-in. guns, are moulded with the head downwards. The mould is lined with a gannister composition, used by steelmakers to stand the high temperature. Suitable core prints are formed at each end. The hollow interior is formed by placing in a core, which is formed round a spindle. This is covered with asbestos, and over this again the "compo." To ensure sound casting, it is necessary for it to have a large superimposed head to compress the metal, and to ensure that it is fed to all parts of the shell. Moreover, the occluded gases and the poorer metal rise up into this head, which is afterwards cut off. The shells as cast are then annealed for twenty-four hours before passing on to the machine shop, where the processes that follow are somewhat similar to those for armour-piercing shell, except that they are tested by internal pressure.


53, ELECTRIC PRIMER

Fuses. Several types of fuses are shown in 50, 52 and 54. The large percussion [50] consists of a stamped manganese bronze body. In firing the gun the piston pressure plate PP is blown in; this collapses the supporting ring—which is made of drawn pure tin tube—as shown in 50. This, by pushing up the bridle, releases one of the centrifugal pellets. These pellets fly outward. The detonating pellet with its cap is then free, and lies back at the base; but on striking it moves forward, the fixed needle above piercing the cap. The flash from this ignites the powder in the pellet and that around the needle plug, thus communicating with the burster inside the shell. This latter action is clearly shown during flight at C.



54, COMBINED TIME AND PERCUSSION FUSE



Small Percussion Fuses. These [52] are made of gunmetal for the small sizes, and steel for the larger. They contain the detonating composition in a recess in front. Below this is the lead guard pellet, supported by the roughened steel or brass needle that is embedded in it. On the shock of discharge the inertia of the lead guard causes it to set back, arming the needle—that is, causing its point to protrude. During flight the guard, with its projecting needle, lies backwards against the base of the fuse; but on impact it moves freely forward, the needle piercing the detonator and igniting the bursting charge in the shell. The smaller type of fuses are manufactured from rods in turret lathes with hollow mandrels and rod feed. In some later types of machines no less than four rods are manipulated at one time. It is impossible to describe the numerous types of fuses, such as delay action, also electric primers—for one type of which see 53—within the scope of this article. But the combined time and percussion fuse will be described briefly.

Combined Time and Percussion Fuse. This fuse [54] is used principally with shrapnel shell. The composition must burn in a regular manner, and is set to act by time at very short intervals. The principal parts of the time arrangements consist of the body, composition ring, and dome. In addition to this there is a percussion arrangement at its lower portion, to enable the shell to burst on impact in case of failure of the time fuse. This fuse is screwed on the exterior to fit into the shell, and bored out to take the percussion arrangement. The body extends upwards through the dome. The composition lies in the central belt of the body with a ring above it also containing the lighting composition and the hammer, with a steel needle suspended by a copper wire above the composition. There is a hole bored through the ring near the start of the composition channel to allow the gas to escape. The outsid of the ring is divided into eighteen half-seconds time of burning. The are further subdivided. The dome fits over the composition ring, and is held in place by the nut screwed on to the stem on top of the body. The action of this time part is such that, when the fuse is set, the shock of discharge causes the hammer to shear the wire, and fire the detonator and composition ring, which burns round the distance required, firing the charge in the horizontal channel, and the bursting charge in the lower chamber of the shell by passing down the primer tube, and thus explodes the shell. The percussion part is shown "before firing" and "during flight," to illustrate its action.

Either portion of this fuse can be used as desired, for time or percussion. The body is made out of bronze bar in a hollow mandrel lathe.

Continued

MUSICAL INSTRUMENT MAKING

The Making of Brass and Wood-wind Instruments, dealing with Processes Involved and Materials Employed

Following on page 6444

By J. P. LORD

IN actual practice, the trade of musical instrument making is divided and subdivided into innumerable classes, some makers confining themselves to one instrument only, while others make a variety; and again, in the manufacture of certain instruments, the entire work is distributed between a large number of operatives, while other instruments are practically made from start to finish by one man. For our own purposes of classification, we will divide the range of musical instruments as follows: (1) brass instruments; (2) wood-wind instruments; (3) stringed instruments; (4) pianos; (5) organs; (6) miscellaneous instruments, such as drums and cymbals.

BRASS INSTRUMENTS

The making of brass instruments is one of the branches of manufacture which are divided into two great sections, according as to whether the worker is a mechanic pure and simple, or a musician. That is to say, in theory at least, the actual construction can be accomplished by a man who has little or no knowledge of music, and then the instrument is passed on to an expert, gifted with a fine ear, by whom the final regulating touches are applied.

We will start with the brass—or silver, for that matter, if fancy instruments are to be made—in the sheet, just as it comes from the rolling mill. The metal sheets are of varying thicknesses, from $\frac{1}{24}$ in. upwards. The thinner sheets are used for the highest class of orchestral instruments, which have little wear and tear to withstand, while those instruments which are required for general band purposes are necessarily made of stouter metal.

In theory, every brass wind instrument, with the exception of the trombone, consists of a conical tube of brass, tapering gradually from the mouthpiece to the opening or bell. The fantastic twists and curves so familiar to us all are only theoretically contrivances to make handling practicable. Remember, however, that this strict theory is not borne out in practice, for undoubtedly the form of an instrument has some marked effect on the tone. It is true that a conical pipe of a certain length and of a certain bore will always give the same note; but the quality of that note will be greatly varied by the subsequent bending of the pipe, by the thickness of the metal, and by the sort of metal employed.

Making the Pipe. Now to make our pipe. In practice, it is not possible to make ordinary brass instruments out of one single piece of tubing, so the instrument is built up of a number of sections, preserving as nearly as possible the same taper from mouthpiece to bell. Each of these sections will, therefore, be a frustum of a cone.

The theoretical length of the pipe required being supplied by scientific musicians according to the taper employed by each instrument maker, the first thing to do is to fashion some templets. Disregarding the bell for the moment, imagine a tube of the dimensions you require cut open along the middle line, and flattened out. You will then have a frustum of a triangle, with the base the exact length of the circumference of the cone at its widest part, and the parallel line at the apex equal to the circumference at the mouthpiece. If about $\frac{1}{12}$ in. to $\frac{1}{8}$ in. be added to one side, to allow for overlapping, then such a plate would form a templet for the manufacture of a tube similar to that from which it was made.

In practice, such templets are made from stiff paper, and deal with sections of the tube only, a margin being allowed at the upper end of each for joining to the section above.

Cutting Out the Metal. The templet is laid on a suitable sheet of metal—good brass, we will assume, for the purposes of instruction—and its outline carefully traced out with a sharp-pointed graver, care being taken to avoid wastage as much as possible. With a strong pair of shears, the brass is then cut to the pattern, and laid on the bench in front of the workman. Next, both edges are filed on the slope till the metal has been reduced nearly one half in thickness. The object of this is to prevent the join being too bulky after joining.

Along one edge, then, the workman cuts a series of little nicks with his shears, each nick being between $\frac{5}{16}$ in. and $\frac{1}{4}$ in. in depth, according to the portion of the tube which is being made, those on small tubes being smaller than those on large ones. These nicks are placed in pairs, the component members of a pair being about $\frac{1}{4}$ in. apart, and separated from the next pair by a distance varying from $\frac{1}{2}$ in. to $1\frac{1}{2}$ in. The nicks must be perfectly parallel to one another, and parallel to the base line of the templet copy.

The Tube. Now the flat sheet has to be fashioned into a tube, which is done in this way. The workman places in his vice an iron—simply a piece of steel bar, tapered more or less to the cone which the tube is to assume. For straight tubes, the iron will, of course, have no taper.

Round this iron the workman proceeds to bend his plate of metal, hammering it, where necessary, with a boxwood mallet, but being very careful not to spread the metal at all by too vigorous hammering. With a little coaxing, the sheet soon bends round, and the filed edges are made to overlap to the extent allowed for in the pattern. The edge is lightly hammered down and adjusted, so that the two ends of the tube are even, and the join does not show a "step" at either top or bottom.

All being right, the tube is now opened again a little, the strength of the fingers being generally sufficient to do this, for the tube in its present stage forms a curved brass spring, and the small pieces of metal between the parallel nicks are prised up with a tool which resembles a small screwdriver with a slit in its edge. When the little slips of metal have been prised up the plain edge of the other side of the tube can be slipped under them. These little pieces of metal thus form a set of small dovetails, or "clems," as they are called.

When the plain edge has been adjusted under the clems in a straight line, the upstanding clems are hammered flat over the sound edge, and the whole joint is well beaten down. The object of first

thinning the edges of the metal sheet is now apparent.

After the joint has been tightly fixed by hammering, the tube has to be finally joined by brazing.

The Process of Brazing. Brazing, in this class of work is performed in this way. A little of the purest spelter is mixed with finely-powdered borax, well moistened with water. This mixture is laid along the parts to be brazed. The tube is then gradually brought up to the melting point of spelter, either in a forge or in a blowpipe flame. The instant the spelter runs the heat must be reduced.

There are certain precautions to be observed if success is to follow. First of all, the portion charged with the brazing mixture must be directed away from the flame till the whole tube is hot, otherwise the borax would bubble up and vanish, and brazing would be an impossibility. When the tube is nicely hot, then the mixture sets, and will no longer bubble. The heat is then applied to and around the proposed joint, and the brass becomes red-hot. Spelter melts some two or three degrees below the melting point of pure brass, and so the joint must be watched very carefully, for if the heat is not reduced the instant the smelter runs, a hole would certainly be burnt right through the tube, and the work either ruined or a difficult repair rendered necessary. Once the spelter has run, it is carried by the borax right along the joint, firmly uniting the metals. Should there be any danger of the joint springing open when heated in the brazing furnace, before the spelter runs, then the tube must be bound together with iron wire, to hold the joint in position.

When the tube is cool again, it will be seen that right along the joint there is a ridge of metal. This is now roughly taken off with a rasp, and the tube then put upon an iron of suitable size. The metal at the joint will be felt to present a ridge inside, if the finger be inserted, and this ridge must now be removed. The tube is held firmly on the iron, and the ridge and surrounding metal beaten with small, curved hammers till the surface is quite even, and till the inside is quite smooth. On examination, it will also be found that the metal along the joint has now been reduced to the thickness of the plain sheet from which the tube was fashioned.

This beating may have unduly hardened the brass at the joint, and so it is sometimes advisable to anneal the tube at this stage. Annealing is simply heating the tube till a dull red is produced, and then allowing it to cool slowly. It is a proceeding which must be resorted to whenever the metal has been consolidated by much hammering.

The rough tube must next be made perfectly cylindrical, and this is done by placing it on irons and beating it with hammers, while it is repeatedly turned round and round. The soft brass very rapidly follows the curvature of the iron, and a tube with a perfectly circular section is thus obtained.

Making the Bell. The bell is made from a very wide-mouthed cone. After it has been joined up into tube form, as in the foregoing directions, it is placed on a series of conical irons and beaten out to shape, frequent annealing being necessary. The final irons exactly correspond with the ultimate curvature of the bell.

All the various sections of the tube being thus prepared, the next task which faces the workman is the bending of all those which require to be bent. At first sight, this seems a very difficult operation, but in reality it is not so, a little care being all that is necessary.

Bending the Tubes. From experience we know that if we attempt to bend a straight piece of brass tube we can do so easily enough, but the tube will be flattened a good deal in the process, while ugly puckers will show on the inside of the curve. To prevent a good deal of the flattening, and to enable us to remedy the puckering, we must support the tube inside in some manner, and in practice this is done by filling up the tube with molten lead. If the lead is not over-heated, no harm whatever is done to the brass, and the gradual cooling of the mass makes the brass very soft and removes a good deal of its tendency to split.

The tubes being filled up with lead and cooled, the workman takes one and begins to bend it, having a pattern before him of the exact curve he wishes to impart. The bending is accomplished in various ways. Sometimes one end of the tube may be loosely gripped in the vice, and the end bent round, a little at a time, till the correct curve is arrived at; at other times a wooden pattern of the curve or a metal one is taken, and the lead-lined tube forcibly bent round it. The latter is the method employed, to give the beautiful circular form to French horns and instruments of that pattern.

But you must be very careful only to bend a very small section at a time, if bending without a fixed frame around which to bend. If not, you will find that instead of having a series of small, low ridges on the inside, there will be a lesser number of high ridges, with narrow bases, and the tube will be ruined when the next stage is reached.

Levelling the Inside of the Tube. When the bending is completed, and the curves exactly represent the models, if you examine the tube you will see that the outside is a little flattened, and could it be gauged you would find that the metal there was thinner than on the inside. The inside will be one mass of fine puckers, with broad bases, extending evenly all round the curve. These must now be removed. Laying the tube on a wooden block, the inside is hammered with wooden or metal hammers, each of the little mounds being beaten down smooth, the extra metal being thus distributed all over the interior surface of the curve. Had you been too hasty or violent in the bending, when you came to beat down the high, narrow-based ridges which would have been formed you would have found that instead of being easily reduced to the level, these ridges would have bent over, and the metal would have split right across the tube, which would have been utterly spoilt.

When the tube has been beaten and coaxed into shape after the bending, it is strongly heated till the lead melts sufficiently to be poured out. It is not necessary that the whole of the lead should be fluid; a very little melting will often suffice to enable the bulk of the metal to be shaken out of the tubes in a lump.

After slow cooling, the curves are now drawn through drawplates, and then placed on bent irons, and the final circular shape restored. If these operations have been carefully performed, the bend will look perfectly cylindrical, and the tube will show no trace of the puckering which it has undergone.

The surface of the tubes is now partially finished off, first of all by rough filing, followed by the use of a steel scraper, which in its turn is followed by polishing with strips of emery paper or cloth, till a fairly high polish is obtained, and all file-marks and scratches are removed. This is done to make the final polishing easy to accomplish when the instrument is put together.

The portions of the tube are then joined together, and it will be found that in the centre there is a vacancy. This is where the pistons and the piston work is to go. The joints are made with fine silver solder, run in very neatly. When the joint has set the excess of solder is carefully removed with a scraper, and the edges polished neatly, till it is difficult to detect the solder in the join.

The principle upon which the pistons act is simply the diversion of the column of air from one track to another. In ordinary instruments the pipes connected with the pistons are truly cylindrical, and this makes some of the high notes difficult to obtain. A firm of instrument makers have, however, recently invented a method of making the pistons and leads from one piston to the other conical, so that the taper is preserved throughout the entire instrument. The leads are the portions of curved tubing which the depression of the piston adds to the length of the total tube, and so lowers the pitch.

The pistons consist of a cylinder of metal, having inside it a metal plug, which is maintained at the top of the cylinder by a spring. On depressing the key the plug is pushed down. The plug is bored at various points to form channels for the air. The borings have to be lined with pieces of tube, neatly soldered in, and the openings must exactly fit the holes in the cylinder where the tubes of the instrument or of the leads are joined.

Tuning Slides. However accurately an instrument may be built, it is impossible to be quite certain that, when finished, it shall be exactly of one pitch, and so some means must be devised by which it can subsequently be regulated. Furthermore, as there are slight variations in pitch between even first-class orchestras, the player must be able to bring his instrument into complete accord with those playing with him. To make this possible, one of the loops, generally close to the mouthpiece end, so that the wind passes through it before reaching the pistons, is made to slide in and out of the two sections which it unites, instead of being firmly fixed at the joints, thus enabling the musician to lengthen or shorten the tube within certain limits. Thus the pitch can be raised or lowered a little. When the pitch is thus altered, the lengths of the tubes added by the pistons would be incorrect for the new pitch, and therefore a similar arrangement has to be made in the leads, so that they, too, can be made longer or shorter, and so brought into proper proportion to the entire tube length of the instrument. The simple sliding tube has been found the most efficient method of arranging the tuning of brass instruments, and is in general use, but it must be mentioned that various complications of it are to be found in strictly fancy instruments made by some manufacturers, who seem to rejoice in elaborate mechanism.

The Key Valve. One modification, however, must be mentioned, because of its general utility. While effecting the tuning of the instrument in the ordinary manner, by means of the common tuning slides, it is often advisable to be able to change the entire key of the instrument rapidly. This can be effected by means of a valve which adds sufficient length to the tube to lower the pitch a semitone or a tone, as may be desired. The leads of the piston work are then fitted with stops, which enable them to be drawn out the correct amount at once, without any tuning by ear. This extra mechanism is found to be of great assistance to French horn players and to cornet soloists.

Though the method of making curved tubes already given is that employed for the bulk of the bent work in brass instruments, yet certain curves are better constructed in another manner. Very small curved pipes, such as those between the first and second piston, and very large curved pipes, like those at the bottom bend of the huge brass bass instruments, are better built up than actually bent. This is because in the former case there is not sufficient material to work comfortably, and because the curve is so acute that puckering is unavoidable, and in the second case because of the great difficulty of properly bending a tube of, say, 3 in. diameter, filled with lead.

How a Curve is "Built." The method of building is simple enough. For very small curves, such as those in the valve work of a cornet, the tube is built in two pieces, each of which is beaten out of a curved piece of brass plate. The joins are down the outside and along the inside of the curved tube, so the sheet, before curving, will represent two U's. The curving, or hollowing, is accomplished by beating the metal on a piece of wood which has a groove cut in it of the proper curvature. Practical brass instrument makers have a number of apparently worthless pieces of wood, with rough, worn hollows in them. These are the wooden blocks on which their most reliable work is beaten, and to the workers are very valuable. The two U's, being beaten hollow with small hammers till the two halves fitted together make a perfect curved tube, have clems cut in them, and then are brazed in the same manner as the main tubing. The final rounding of the tube is effected on a curved iron.

Joining the two Tubes. Sometimes the bent tubes for the large brass bass instruments are built in the same fashion, but more often it is more economical to make them in two unequal-sized parts. The width of the two portions is the same, but one is much longer than the other. The reason for this is plain when we note that one piece forms the whole outer half of the curve, while the other makes the small inner portion of the same, the joins being along the sides. Both these portions are fashioned simply by hammering on blocks of wood, but while the longer piece must be bent with the curved hollow turned towards the inner portion of the U, the smaller piece has its hollowed side on the outside of the U. Both pieces are then brazed together, the joints cleaned up, and the large tube finally brought to a perfect round by hammering on irons. After cleaning and polishing, it is then ready to take its place in the instrument.

The Finishing Process. When the pistons have been fitted to the instrument the finisher takes it in hand and solders on the various supporting stays which help to keep the whole mass of tubes together. The outsides of the curves of large instruments are reinforced with strips of brass plate soldered on to protect the tubing from dents, and neat little collars are fastened round the ends of the tubes into which the slides go, and at the place where the crooks, or lengths of tube used for altering the pitch, are inserted between the mouthpiece and the main tube. Every visible scrap of solder is scraped and burnished away, and then the polish is finished off with a strip of rag sprinkled with a little Tripoli powder. Prior to the final polishing, however, a musical expert takes the instrument in hand, and tries it, to make sure that it is in tune and that there is ample play allowed for the tuning slides to permit of any reasonable differences in pitch being compensated for. If he finds that such is not the case, either fresh slides have to be fitted, or some portion

of the tubing replaced by a longer or shorter bit, as the case may be. Generally, it is desirable that the slide should be a little drawn when the instrument is tuned to give its normal pitch. This makes it possible both to sharpen and flatten the pitch, as occasion may require. The tone of the instrument and the facility with which the harmonic notes can be obtained will at once tell the expert if the tubing is absolutely faultless. His branch of the manufacture cannot be taught. Considerable natural talent, a marvellously accurate musical ear, and long experience are absolutely necessary.

Of the plating and engraving on musical instruments we shall not treat here, those being portions of the silversmith's craft [see page 5528, also METAL COATING].

Straight-tube Instruments. Instruments of the trombone and tuba class are not made with conical tubes, always excepting the short bell length. They can be made from tube constructed as indicated, or from hard drawn tube. The slide trombones and slide trumpets have no valves, but one of the U-tubes slides in and out of the limbs for a very long distance, and the lowering of the note in actual playing is thus effected, instead of by the addition of lengths of tube by means of the pistons. The movable portion in these instruments slides over the fixed portion, a point which must not be lost sight of.

Saxophones, sarrusophones, and ophicleides, which are conical brass instruments played by means of holes covered with keys, have their tubes made in the same way as ordinary brass instruments; but the holes are bored in the completed tube by means of an instrument similar to that which is used in making wooden instruments, which are there described.

WOOD-WIND INSTRUMENTS

The making of wood-wind instruments is a much more exacting branch of the instrument-maker's calling than the manufacture of brass ones. The reason is simple. You cannot add pieces to a wooden tube without injuring its resonance, so from the first you must accurately determine the length of each section. Again, if a hole is wrongly bored, it cannot be filled up and rebored, save for purposes of experiment. Added to this, there is the danger of splitting, inherent in all wood. Greater delicacy of workmanship is therefore necessary if first-class results are to be obtained.

The first players managed with a simple reed, crushed, and with a few rude holes pierced in it; to-day, the choicest woods of the world have to be sought if tone is required. Formerly, boxwood was employed in making wind instruments, but owing to its power of absorbing moisture, and so altering the tone of the flute or clarionet made of it, it is now regarded as unsuitable. Other woods, possessing the necessary degree of hardness, have an awkward knack of splitting without any apparent cause, and so have to be rejected, and for all practical purposes the choice of woods is now reduced to those we shall mention. Cocus, a very hard, brown wood, heavier than water, and imported from the West Indies, is the best all-round natural wood used. It is suitable for making flutes, clarionets, and piccolos, and is capable of giving a rich tone. It does not split readily, is very handsome, and not very treacherous to work. Rosewood is used for oboes, cor anglais, and bassoons. It is a little softer than cocus, and not quite so heavy. It is not a very easy wood to work, requiring a great deal of experience if the best results are to be obtained. Maple is sometimes used for bassoons on account of its lightness, but it is not nearly so reliable as rosewood, and is not much cheaper.

The Use of Ebonite. The most popular material at present for the making of wood-wind instruments which are likely to have to withstand rough usage, or great extremes of temperatures, is not a wood at all, but is a compound of indiarubber and sulphur, known in the musical trade as ebonite, and to the general public as vulcanite. The tone of ebonite instruments is not quite as perfect as those of the best quality wood, but as they are practically imperishable, never cracking, and not being affected by heat or cold, their advantages outweigh this slight loss of quality for all ordinary work.

The wood for instruments comes to England in logs, each of which weighs from ½ cwt. to 1 cwt. It is then stored away from the heat of the sun, protected against draughts and frost, for a number of years, till it is perfectly seasoned. When the time comes for it to be worked up it is split into billets suitable for the size of the instrument to be made. If it were sawn it would be much more liable to split in the subsequent operations, and many a defect, which splitting reveals, might not be discovered till the flute or bassoon was finished, when so much labour and time would have been wasted.

Turning the Wood. After being split into billets the wood again lies by for a short while, and is then roughly turned. This preliminary turning, simple as it sounds, is really a very important operation. The lathe used is one of the old-fashioned overhead pole lathes, the wood being revolved by a cord passed round it, and turning between dead centres. The object in using this pattern lathe is because it enables the turner to note any flaw in the wood, and by slightly shifting his centre to cut it out, still leaving sufficient sound wood to make a first-class instrument. The pole lathe also enables the turner to leave a raised boss on any part of the wooden cylinder he is working upon should he require to do so. In these days when metal pillars are used for all good keyed instruments, this is not a very important point, but in the making of low-grade instruments, with the keys working between bosses, it is a most useful factor in the lathe.

The wood having been roughed out, it is again examined, and if it passes muster, it is turned down to the extreme outside measurement of the instrument under construction, and again allowed to season for a short while to see if any cracks reveal themselves. The ends which are to fit into other joints are then turned to measurement and the instrument in embryo is ready for boring. It must be remembered that in working ebonite all this seasoning has not to be undergone, and so the manufacture is a more speedy business. Contrary to popular ideas, the ebonite is turned and worked exactly like wood; anything savouring of moulding would result in absolute failure.

Boring Wood Instruments. Much depends on the bore of a wooden instrument, and for a long time experts carried on active warfare over the respective merits of conical bores and cylindrical ones. The best flutes nowadays are made with a cylindrical body and a slightly conical head, the smallest portion of the cone being close to the cork which closes the upper end. This cone is said to be parabolic in section, but the parabola is so acute as to equal a cone to all but a mathematician. Oboes have a conical bore, while a great deal of the bore of the clarionet is cylindrical. The bassoon is a perfect cone, though the taper is very gradual indeed, as might be expected from its great length.

Both cylindrical and conical joints are bored in the same manner—namely, by a species of revolving gouge mounted on a mandrel of a lathe. This magnified drill is exactly of the diameter of the inside of the instrument under construction, and, of course, for instruments with conical bores, is cone-shaped. It has a cutting edge along its whole length. The billet of wood being fixed in position, the drill is started revolving, being entered exactly in the centre of the end of the wood, and allowed slowly to eat its way through the entire section, the wood being slowly fed up to it. Absolute accuracy is essential in this operation, and a variety of devices have been invented for keeping the wood in a dead straight line with the centre of the drill during the process, but the best manufacturers do not make use of these mechanical guides to any great extent.

The great danger in boring is the splitting of the wood, for it can be easily understood what a strain there must be on the fibres of the wood—say, of a bassoon joint some 2 ft. or more in length, with a conical drill, every fraction of whose edge during its whole length is actually cutting, revolving within it.

The "Butt." The butt, or foot joint of the bassoon requires two holes bored through its entire length, the smaller being bored from the bottom to the top, and the larger from the top to the bottom, for the first hole is wider at the bottom than at the top, while the larger hole is much wider at the top, the bottom being the same size as the largest diameter of the smaller hole. This is because in the foot the doubling of the bassoon pipe is effected, the bell of the bassoon, and consequently the widest part of its bore, being above the performer's head.

When the drilling is finished the inside of the tube is perfectly smooth; so finely do the drills cut that no sand-papering or other trimming is generally necessary. Here it may be mentioned that some manufacturers believe that the less sandpaper is used in the making of wood-wind instruments the better the resulting tone.

After the drilling, and sometimes before the wood is drilled, the outside is polished up on the lathe in the ordinary way. The wooden cylinders are then laid aside, standing in racks, for about three or four months, and kept at an even temperature. If the boring has caused any small cracks they will show themselves in this time, and further labour need not be wasted on the wood. This additional period of seasoning is also necessary to enable the internal portion of the wood to get thoroughly accustomed to the action of the air.

The Borings. Up to this point the cylinders, or conical tubes, have been made exactly to a fixed scale of measurements, these measurements differing according to the instruments under construction and the peculiarities of the individual maker. Consequently, as they all are of similar lengths, they would all give the same note, since the bores are the same. It follows, therefore, that if the holes are correctly placed on one of these pieces of wood, to give the proper notes, then if the holes on the others are placed in the same positions, all will give the same scale, with the same degree of accuracy, allowing for very minute alterations. Recognising this, first-class makers have adopted a machine which enables them to exactly copy any set of borings on any flute.

This piece of apparatus works in this way. Between two clutches the model is fixed, and, exactly parallel to it and about three inches below it, the cylinder to be bored is also secured by screw clamps. Travelling along a rod, parallel to the model and object is a small drilling lathe driven by a cord from some overhead source of power. The block carrying the drilling tool can be advanced in a straight line at right angles to the model, and towards it. The cutting drill, selected acording to the size of the hole, and revolving at a high speed, is on the face of this block exactly opposite the centre of the object wood. Above it, and of exactly the same length as the drill, is a plain, round steel rod. The size of this varies exactly as that of the drill. This steel rod acts as a guide and a check at the same time. The cutter beneath it can only advance just as much as this rod advances, and is bound to move strictly parallel to it. The model and the wooden tube beneath it are so mounted that if the model is revolved on its long axis through a certain number of degrees the wooden tube moves at exactly the same rate through exactly the same number of degrees; whatever is done to the model is copied faithfully by or on the object wood.

Cutting the Holes. The body tube of, say, a first-class flute which is perfectly tuned is selected as a model for flute bodies. All the keys are stripped off, leaving just the tube and holes, including even the small holes into which the key pillars fit. This is placed in the upper part of the machine, and in the lower is placed one of our seasoned cylinders of wood, which we propose to bore, and so transform into the body of a good flute.

A cutter and steel touch are selected of exactly the size of the large holes on the model. The touch is put into the upper part of the travelling lathe, and the cutter fixed to the lower spindle. The power is then turned on and the cutter, or drill, begins to revolve. The steel touch is now brought opposite to the first hole on the model, and introduced into it gently, the cutter beneath forcing its way into the wood of the copy to just the depth that the touch passes into the model. The hole is thus neatly and rapidly bored, and as far as position is concerned it is exactly the same as the first hole in the model, which is known to be correct. The other large holes are bored in the same manner. Then the power is turned off, and the cutter changed, as well as the touch, to suit the smaller key holes on the model. As the model is turned to bring these exactly opposite the touch, the copy follows it, and so the holes are again placed in their correct positions.

Preparing the Beds. Now, if you examine the holes of a good flute—that is, one with all holes covered, for uncovered holes do not require beds—you will notice that round the top of each hole the wood is sunk a little, and a still deeper groove, with a convex surface, leads from the extreme rim of the sunk portion up to the flat bed on which the pad of the key presses. To make these beds, a circular cutter with a concave surface is placed on the lower machine, and a touch corresponding to the entire surface of the bed put on the upper guide holder; or a plain large touch is placed on the upper machine holder, the depth of this particular groove being gauged by eye. The travelling lathe is then advanced, and the cutter follows, cutting a ring round the first holes, but the ring has a well-defined convex surface, since the cutter has a concave surface. When all these rings have been prepared, the flat beds are cut in much the same manner, only the cutter has a perfectly flat surface which just takes off the crest of the convex rim already cut. Thus neat, level beds are made, which will

enable the pads of the keys to "bite" nicely, and stop the holes accurately.

For other instruments the process is exactly the same. Wherever the touch goes, the cutter faithfully follows, only it cuts its own path in the copy. The slanting holes in the wing joint and the butt of a bassoon can be cut with this ingenious machine, for the travelling lathe can then be made to move in an oblique direction to the axis of the model, and consequently to cut oblique holes in the copy. It is obvious, too, that by replacing the revolving cutter by a fixed chisel, and permitting the copy to revolve, as well as the model, between centres, any inequality on the model could be reproduced on the copy, were it worth the trouble.

Tips, Rings, and Joints. According to the practice of the manufacturer the end rings, and joints of cork and linings are placed in the tubes either before the holes are drilled or afterwards. The wood is turned accurately to fit the rings, which are gently forced on, great care being exercised not to split the wood, or to strain it. There is nothing special in this branch of the trade, neat and accurate fitting being the sole essential. Where a flute head is lined, the metal tube is also inserted at this stage.

The pillars and rods and levers which go to make up the mechanism of the key action on wood-wind instruments are made either of silver or German silver. Their construction forms a neat branch of silversmith's work. The pans to hold the pads are stamped in a die press out of the metal sheet; the shanks and rods are fashioned out of silver or metal rods, or stout wire. The various component parts are joined together with fine silver solder, and polished and burnished up. The pads are of stuffing, covered with the finest skin. They are fixed in their pans either by a central screw, with a washer, or by means of cement.

Finishing. The bored tube of the instrument, with a supply of pads, levers and other mechanism is now handed over to a finisher, who proceeds to build up the instrument. Where the pillars are attached directly to the wood, the finisher has to tap a fine screw thread in each of the pillar holes in the tube, and screw in the pillars. When the bulk of the mechanism is on a long plate, this has to be screwed down on to the side of the tube. To the plate the pillars have been previously riveted. The finisher then puts in the keys and levers in regular order, depending upon the model of the instrument he is making. The little needle springs he inserts in the holes in the pillars with pliers, and tests them to see that they are not too strong, and yet sufficiently firm to close the holes tightly. This sounds as if it were a rapid job, but, as a matter of fact, it is very long and tedious, for no mechanical assistance can be given, and the whole of the adjusting has to be done by hand, with the greatest patience. It is one long task of filing and scraping, a little here and a little there, till each of the keys works perfectly by itself, and also works properly in conjunction with others if intended to do so. The finisher must be an instrumentalist, at least in as far as ability to play scales in every key on the instruments committed to his care is concerned; he should be gifted with a fine ear and a fine perception of tone.

When he has accurately fitted up the instrument, and tried it, being satisfied that the mechanical requirements are duly fulfilled, then the finished flute, or oboe, or bassoon, or whatever it may be, is passed to the expert, who decides whether the instrument is truly in tune throughout and perfect in every respect. If he finds one or two notes a little faulty, he gives instructions for their adjustment, either by removing a little wood from the bore of the tube at certain spots, or by altering the hole a fraction. If more than slight, but at the same time important, alterations are necessary, the best makers reject the instrument as unworthy to bear their name—and it would be well for the world of music if everybody did the same.

Fitting the Parts Together. Sometimes it may happen that while the individual joints of a wooden instrument are perfect, they do not work well together, and then the labour is not lost, as the parts can be built up in other instruments. The cause of this curious disagreement is not understood, for it has been known to occur when every part of a particular instrument has been built from the same log of wood, and from actually adjoining portions. To make a good examiner of wood-wind instruments, the artist must have a good theoretical and practical knowledge of the laws of sound, and must add to this a wide experience. It is a position only attained after years of close acquaintance with this class of instrument. The oboe, cor anglais, and bassoon are made in strict tune with the recognised concert pitch, and are incapable of alteration. The clarionet can be flattened a little by very slightly drawing out the head joint. The flute is best made so as to be up to concert pitch when the head is drawn out on the tuning slide about a couple of millimetres. In the opinion of some people, the flute can be flattened a good deal; but, as a matter of fact, it bears flattening very badly, for it stands to reason that if the holes are properly placed for one position of the slide, they must be wrong for all other positions.

Repairing Wind Instruments. The repairs to brass instruments are few in number and, in the majority of cases, of a very simple nature. The pistons may get out of order and their adjustment is only a matter of a few minutes for the man who made them—or the tube may get badly battered. Very often a battered tube can be restored to a playable condition without resulting loss of tone by removing the section from the instrument and shaping it again on the irons. Occasionally the job may be better and more economically done by fitting in an entirely new piece of tube of the proper calibre and thickness. Anything which savours of "soldering up a crack" is "botching" of the worst description, and cannot be called true repairing.

Wood-wind instruments suffer from one great ailment—namely, cracking, a fault which ebonite instruments are free from. Cracks, if not very bad, can often be stopped with composition very neatly, and no great loss of tone results. The famous flute player, Ciardi, played on an instrument with a terrible crack right down the head joint, yet his tone was as near perfection as has yet been attained, always excepting that produced by Nicholson. Defects in the mechanism of the keys are also frequently met with, being caused by a blow or a fall. These can either be rectified by the finisher, or may necessitate a new key being made for the instrument. Sometimes valuable instruments are accidentally damaged beyond repair.

Continued

SIDES AND ANGLES OF A TRIANGLE

Logarithms. Formulæ Connecting the Sides and Angles of a Triangle. Four Cases of Solution of Triangles

continued from page 6500

By HERBERT J. ALLPORT, M.A.

LOGARITHMS—continued

31. The decimal part of a logarithm is called the *mantissa*: the integral part is called the *characteristic.*

The logarithms of two numbers which have the same digits in the same order (i.e., they differ only in the position of the decimal point) have the same mantissa.

For example, let the numbers be 147·2 and ·01472. Then

$$147{\cdot}2 = {\cdot}01472 \times 10^4.$$
$$\therefore \log 147{\cdot}2 = \log {\cdot}01472 + 4 \log 10$$
$$= \log {\cdot}01472 + 4.$$

Hence, by keeping the mantissa always positive, the logarithms of numbers expressed by the same digits will only differ in the characteristic. Now, the characteristic of the logarithm of a given number can always be obtained by inspection. From Article **30** it is evident that

(i.) The characteristic of the logarithm of a number greater than 1 is *one less* than the number of *integral* figures in the number. Thus, characteristic of log 549·287 is 2, since there are *three* figures in the integral part, 549, of the number.

(ii.) The characteristic of the logarithm of a number less than 1 is negative, and is *one more* than the number of noughts between the decimal point and the first significant figure. The characteristic of log ·000582 is -4.

In order to denote that only the characteristic is negative, and the mantissa positive, the negative sign is written *over* the characteristic, and not *before* it. Thus, if the logarithm of a number is $-2 + {\cdot}8257143$, it is written $\bar{2}{\cdot}8257143$.

Since the characteristic is found by inspection, the mantissa only is printed in the book of logarithms. For example, opposite the number 59082 we find 7714552. This means that 7714552 is the decimal part of the logarithm of any number which consists of the digits 59082 in that order. Thus, log $5908{\cdot}2 = 3{\cdot}7714552$; or log $\cdot059082 = \bar{2}{\cdot}7714552$.

32. Books of logarithms vary in detail, but all of them contain instructions for using their contents. In *Chambers' Mathematical Tables*, mentioned in Part 44, the use of the tables is explained by many worked examples, which the student will find no difficulty in understanding. The only thing we need refer to here is the *Rule of Proportional Differences.* The tables give the logarithms of numbers from 1 to 100,000, *i.e.*, number of five figures. The above rule enables us to find, by means of the tables, the logarithms of numbers having six or seven figures.

The rule is that *when the differences between three numbers are small compared with the numbers these differences are proportional to the corresponding differences between the logarithms of the numbers.*

EXAMPLE. Find log 33651·4, having given that log 33651 = 4·5269980 and log 33652 = 4·5270109.

Let log $33651{\cdot}4 = 4{\cdot}5269980 + d$.

Then, we have three numbers: 33651, 33651·4, 33652. The differences between the first and second and between the second and third are ·4 and 1. Again, we have three logarithms corresponding to the numbers, viz.:

$$4{\cdot}5269980,\ 4{\cdot}5269980 + d,\ 4{\cdot}5270109.$$

The corresponding differences are d and ·0000129, and they are in proportion, so that

$$\frac{d}{{\cdot}0000129} = \frac{{\cdot}4}{1},$$

whence $d \doteq {\cdot}0000052$ (to seven places).

$$\therefore \log 33651{\cdot}4 = 4{\cdot}5269980 + {\cdot}0000052$$
$$= 4{\cdot}5270032.$$

33. The logarithms of the ratios of all angles from 0° to 90° have also been tabulated. Sines and cosines are less than 1, and so also are tangents of angles between 0° and 45°. The logarithms of these ratios will therefore have *negative* characteristics.

To avoid printing these negatives, the number 10 is added to each logarithm. The result is called the *tabular* logarithm of the sine, cosine, etc., and is indicated by the letter L. Thus, in the tables we find L tan 35° 4′ = 9·8463018, so that log tan 35° 4′ = 9·8463018 − 10 = $\bar{1}{\cdot}8463018$.

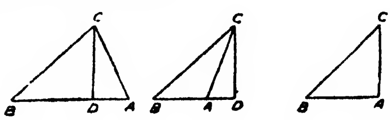
The rule of proportional differences is applied in the same way as in the case of numbers, so that from the logarithms of tan 35° 14′ and tan 35° 15′ we can find log tan 35° 14′ 25″, say.

Sides and Angles of a Triangle

34. In a triangle ABC, the letters A, B, C are used to denote the number of degrees in the angles at the points A, B, C respectively; so that "sin A" means "sine of the angle at A." The letters a, b, c, denote the lengths of the sides BC, CA, AB, *i.e.*, the sides opposite respectively to the points A, B, C.

35. *To prove that* $\cos A = \dfrac{b^2 + c^2 - a^2}{2bc}$.

Since a $\triangle$ has at least two acute angles, one of the angles B, C, must be acute. Let B be acute. Draw CD $\perp$ to BA or BA produced. In the three cases, where A is acute, obtuse, or a right angle, we have



(1) $BC^2 = CA^2 + AB^2 - 2\,BA \,.\, DA$ (*Prop.* 69);
or, $a^2 = b^2 + c^2 - 2c \,.\, DA$.

But $\dfrac{DA}{AC} = \cos A$, so that $DA = b \cos A$.

$\therefore\ a^2 = b^2 + c^2 - 2bc \cos A$.

(2) $BC^2 = CA^2 + AB^2 + 2BA \,.\, AD$ (*Prop.* 70);
or, $a^2 = b^2 + c^2 + 2bc \cos DAC$.

But $\cos DAC = \cos(180^\circ - A) = -\cos A$.

$\therefore\ a^2 = b^2 + c^2 - 2bc \cos A$.

(3) $BC^2 = CA^2 + AB^2$

$\therefore\ a^2 = b^2 + c^2 - 2bc \cos A$,
since $\cos A = \cos 90^\circ = 0$.

Hence, in all three cases we have

$$\cos A = \frac{b^2 + c^2 - a^2}{2bc}.$$

Similarly,

$$\cos B = \frac{c^2 + a^2 - b^2}{2ca},\quad \cos C = \frac{a^2 + b^2 - c^2}{2ab}.$$

36 Let $a + b + c = 2s$.
Then $b + c - a = b + c + a - 2a = 2s - 2a = 2(s - a)$.
Similarly, $c + a - b = 2(s - b)$,
and $a + b - c = 2(s - c)$.

37. *To prove that*

$$\sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}},$$

and

$$\cos\frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}.$$

We have $2\sin^2\dfrac{A}{2} = 1 - \cos A$ [Art. 26]

$$= 1 - \frac{b^2 + c^2 - a^2}{2bc} = \frac{2bc - b^2 - c^2 + a^2}{2bc}$$

$$= \frac{a^2 - (b^2 + c^2 - 2bc)}{2bc} = \frac{a^2 - (b-c)^2}{2bc}$$

$$= \frac{(a + b - c)(a - b + c)}{2bc} = \frac{2(s-c) \cdot 2(s-b)}{2bc}.$$

$$\therefore\ \sin\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{bc}}$$

Also,

$$2\cos^2\frac{A}{2} = 1 + \cos A = 1 + \frac{b^2 + c^2 - a^2}{2bc}$$

$$= \frac{2bc + b^2 + c^2 - a^2}{2bc} = \frac{(b + c)^2 - a^2}{2bc}$$

$$= \frac{(b + c + a)(b + c - a)}{2bc} = \frac{2s \cdot 2(s-a)}{2bc}.$$

$$\therefore\ \cos\frac{A}{2} = \sqrt{\frac{s(s-a)}{bc}}.$$

Similarly,

$$\sin\frac{B}{2} = \sqrt{\frac{(s-c)(s-a)}{ca}},\quad \cos\frac{B}{2} = \sqrt{\frac{s(s-b)}{ca}},$$

$$\sin\frac{C}{2} = \sqrt{\frac{(s-a)(s-b)}{ab}},\quad \cos\frac{C}{2} = \sqrt{\frac{s(s-c)}{ab}}.$$

38. From the last article we have

$$\tan\frac{A}{2} = \frac{\sin\frac{A}{2}}{\cos\frac{A}{2}} = \frac{\sqrt{(s-b)(s-c)}}{\sqrt{s(s-a)}}.$$

Similarly for $\tan\dfrac{B}{2}$ and $\tan\dfrac{C}{2}$.

39. Since $\sin A = 2\sin\dfrac{A}{2} \,.\, \cos\dfrac{A}{2}$ [Art. 26].

$$\therefore\ \sin A = 2 \,.\, \sqrt{\frac{(s-b)(s-c)}{bc}} \,.\, \sqrt{\frac{s(s-a)}{bc}}$$

$$= \frac{2}{bc} \,.\, \sqrt{s(s-a)(s-b)(s-c)}.$$

The expression $\sqrt{s(s-a)(s-b)(s-c)}$ is usually denoted by S. Hence, $\dfrac{\sin A}{a} = \dfrac{2S}{abc}$. In the same way we get $\dfrac{\sin B}{b} = \dfrac{2S}{abc} = \dfrac{\sin C}{c}$.

Therefore, in any triangle

$$\frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}.$$

40 *To prove that* $\tan\dfrac{B-C}{2} = \dfrac{b-c}{b+c} \,.\, \cot\dfrac{A}{2}$.

Since $\dfrac{\sin B}{b} = \dfrac{\sin C}{c}$. $\quad\therefore\ \dfrac{b}{c} = \dfrac{\sin B}{\sin C}$.

$\therefore\ \dfrac{b-c}{b+c} = \dfrac{\sin B - \sin C}{\sin B + \sin C}$ [Algebra, Art. 139]

$$= \frac{2\sin\frac{B-C}{2} \,.\, \cos\frac{B+C}{2}}{2\sin\frac{B+C}{2} \,.\, \cos\frac{B-C}{2}} = \frac{\tan\frac{B-C}{2}}{\tan\frac{B+C}{2}}.$$

But $\qquad \dfrac{A + B + C}{2} = 90^\circ.$

$$\therefore\ \tan\frac{B+C}{2} = \tan\left(90^\circ - \frac{A}{2}\right) = \cot\frac{A}{2}.$$

$$\therefore\ \frac{b-c}{b+c} = \frac{\tan\frac{B-C}{2}}{\cot\frac{A}{2}};$$

or, $\qquad \tan\dfrac{B-C}{2} = \dfrac{b-c}{b+c}\cot\dfrac{A}{2}.$

Similar formulæ can be proved for $\tan\dfrac{C-A}{2}$, and $\tan\dfrac{A-B}{2}$.

41 By the aid of the formulæ in Articles **35** to **40** we can solve a triangle when we are given three of its parts, one of the given parts being a side. These formulæ are therefore very important.

Solution of Triangles

42 There are four cases.

(1) Given the three sides.
(2) Given one side and two angles
(3) Given two sides and the included angle
(4) Given two sides and the angle opposite one of them.

43 Given the three sides a, b, c.

From any of the formulæ of Articles **37** and **38**, we can calculate two angles, say **A** and B. The third angle is $180^\circ - A - B$.

For logarithmic computation these formulæ are adapted as follows

$$\tan\frac{A}{2} = \sqrt{\frac{(s-b)(s-c)}{s(s-a)}}.$$

$$\therefore\ \log\tan\frac{A}{2} = L\tan\frac{A}{2} - 10$$

$$= \log\sqrt{\frac{(s-b)(s-c)}{s(s-a)}} = \log\left\{\frac{(s-b)(s-c)}{s(s-a)}\right\}^{\frac{1}{2}}$$

$$= \tfrac{1}{2}\{\log(s-b) + \log(s-c) - \log s - \log(s-a)\}.$$

Continued

CIVIL ENGINEERING ABROAD

The Profession and Practice of the Civil Engineer in Greater Britain. The Labour Supply for Engineering Works

Continued from page 6498

By C. O. BURGE

ENGINEERING is more important abroad, for, apart from the question that the area of construction in Europe is largely closed, the magnitude of operations at home have never been, as a rule, on anything like the scale of those abroad, either completed, in progress, or projected, for examples of which we have only to think of such works as the Suez Canal, the Hawkesbury Bridge in Australia, with its foundations 160 ft. below water, the deepest ever reached; the Zambesi bridge, with its bold span of 500 ft. thrown over a chasm of nearly the same depth; and the Coolgardie water supply scheme in West Australia, in which the water is pumped about 1,700 ft. high through pipes extending from the source, near the sea at Perth, to the goldfields 351 miles far inland.

Climate. One of the most potent causes of difference in the engineering conditions at home and abroad is that due to climate. In moist, hot countries, like those near the coasts of West Africa, Natal, India, North Queensland, and other tropical and even sub-tropical regions, the decay of materials, especially ordinary timber, is rapid, and must be provided against by the use of special classes of timber, or by the substitution of stone or metal in works where wood, otherwise, would be better adapted. Heat also saps the energies of the workman—European or native. In India, during the prevalence of the monsoon rains, work and surveys have often to be suspended for lengthened periods, and the same happens in Canada during the extreme frosts and cold of winter.

Even as regards daily hours of work, climate is a factor. Near the Equator it is always unpleasant, and sometimes dangerous, for a European to be out of doors in the middle of the day, and even natives, at certain seasons, start work earlier and leave off later, to allow of a prolonged mid-day *siesta*, and work is often done by moonlight in such cases.

Heat and Design. Heat also affects design: for instance, hesitation to employ underground railways in Australian cities, or long tunnels through its hills, or those of similar regions, is due to the fact that engine-drivers and guards run considerable risks from the heat, accompanied by noxious gases, while going through; while obviously in sewerage schemes, the temperature has to be taken into consideration. On the other hand, snow sheds have to be provided at certain points in Canada to protect railways and other communications from obstruction in winter.

In some districts, more especially inland in Australia, parts of the Cape, and in the Argentine, want of water occasionally occurs for prolonged periods, and the engineer and his helpers sometimes have to go through great personal suffering. There are numerous districts where the water supplies are as much as 50 to 60 miles apart, and great cost is incurred in keeping even a small party supplied. Works and surveys in some cases have had to be temporarily stopped for this reason.

Health. Again, climate has much to do with the health of the engineer abroad, exposed as he is to its vicissitudes more than are most followers of other associations, but in nearly all the warmer climates with which we are dealing, there are highlands with exquisite climates, easy of access, where temporary refuge from the heat and lassitude of the lower levels can be had. In New Zealand, Tasmania, and many parts of Australia, South America, and South Africa, ideal climates exist, superior in many respects to our own, and, in most parts of the world, with youth, a good constitution and temperate habits, and the open-air life, the engineer can reckon on a fairly healthy life.

Labour. In the outlying lands, labour, one of the great means of engineering construction in any country, varies in character, not only from that of the British Isles, but from that of any other. Variety of labour is to a great extent due to climatic conditions. And first as to quantity. In India we have thousands of available hands, almost in every district, not only amply furnishing the unskilled labour, but all the artisans and clerks, and even the foremen and assistant engineers required, and in the case of the first-named, there is double the corresponding force in other lands, for women, as well as men, are found doing navvy as well as other work. On the other hand, in Australasia and Canada, there is a comparatively limited supply of white labour, and in these, as contrasted with India, we find the extremes of high and low wages.

Intermediate to these two extremes of India and Australia are the cases of South Africa, the West Indies, and numerous other places where coloured labour is used chiefly or only for unskilled work, the higher classes, at all events, of artisans' work being done by the whites, while in those parts which are largely dependent on Chinese labour, such as in the Straits Settlements and British Columbia, good skilled labour can be found among its ranks.

Quality of Labour. But we have to deal with quality as well as quantity of labour, and by quality it must not be understood that mere individual effectiveness in strength or skill is meant. If so, the Englishman by birth or descent would generally take a top place. It is the all-round value to the engineer for his purpose which is in question, taking not only physical strength and skill into consideration, but wages paid, trustworthiness, intelligence, manageability, endurance and sobriety, in many of which respects it must be allowed that other races stand higher. In the last-named quality the Indian coolie is pre-eminent, and not only actually, but in proportion to amount of work done, accepts perhaps the lowest reward of all mankind for manual labour. Economists state that the rate of wages for unskilled labour may be divided into two classes—namely, first, the *market* rate, which is that which prevails in the more wealthy communities, and is mainly influenced by the law of supply and demand; and secondly, the *natural* rate, where these laws find their limit, and which represents—having regard to the prices of commodities—the lowest means of sustenance for the workman and his dependants. It is obvious that no supply of labour, however great, can

bring wages below this point, as, should they be lower, the labourer would starve, and the work would end. The labouring classes of India and some other populous tropical countries are, to a great extent, living on natural wages, hence the economical advantage, leaving other considerations aside, of their employment. Thus there is, in India especially, the disinclination of the native to leave his village, and follow the demand for labour, and the absence of any desire to be richer than his forefathers or neighbours. Moreover, his domestic requirements are so few that the women are, as already stated, as numerously employed as the men, and this again tends to lower rates, the latter being direct producers

Oriental Labour. As a rule, the coloured man is nervous about taking risks, the competitive spirit in the face of them being absent, so that, though small contracts are not infrequently taken by them, fortunes are seldom made. Whether it be by day work or piece work, the rates are so low that methods of work, and even designs, differ largely from European standards, as we shall see later. Indian native masons, bricklayers, carpenters, blacksmiths, etc., do quite half as much work as Europeans, for a fourth or fifth of their wages; while an ordinary labourer at earthwork will do a quarter of the work of an English navvy at a seventh or an eighth of his wage. There are exceptions to this, however, in such heavy work as railway platelaying and the like, when it is inconvenient to crowd a sufficient number of hands so as to make up for want of individual strength in each of them. On the construction of the Canadian Pacific Railway, for instance, by white labour, as compared with that of an Indian line, about the same time, the same rate of progress was made in laying and lining up the rails, in the one case, by one-eighth of the number of workmen employed in the other, their wages bearing, inversely, about the same proportion.

Generally speaking, the men on whom the civil engineer in India, Ceylon, and Burmah has to rely are steady, easily controllable, law-abiding, and, to the limits of their strength, which is not great, hardworking.

Similar, in many respects, but more powerful in physique, and readier to take up the risks of contract work, are the Chinamen, who are numerous in the Straits Settlements; in Canada, west of the Rocky Mountains, and in Chili and Peru. They make excellent artisans, and working long hours at low wages, and being orderly and trustworthy, they form about the best material for his purpose that the engineer abroad can find. As to contracts and piece work, the Chinaman knows better than most men how to make a hard bargain; but once made, he can be trusted to carry it out loyally to the end, be it ever so bitter.

African and American Labour. The coloured races of South Africa, and those of the central and western parts, and the descendants of the latter in the West Indies, are physically much more vigorous than those of India generally, but they are impatient of continuous exertion, lazier, and frequently less manageable. Kaffirs save a few pounds on works, and are off generally without notice, sacrificing all pay due, with a few mats and pots, constituting their entire belongings; then, after having arranged for the purchase of a few cows, and perhaps sold a daughter or two, will turn up again for another short period of work. While the comparatively feeble Hindoo works steadily to the limits of his strength, and is easily controlled by his native maistry or ganger, the able-bodied Kaffir of South Africa, and the negro of the West Indies, require more or less forcible persuasion of the white foreman to utilise to the full their robust strength. Owing to this, Natal is obliged, in order to develop her resources, to import Indian coolies, though it is fully peopled by Kaffirs and Zulus, the latter especially being physically one of the finest of the coloured races. Coolies are also imported into Mauritius and Tasmania. The negroes of the West Coast and in the West Indies can be taught trades and do fairly well for skilled labour, but the South African native, as a rule, is good only for ordinary labour; the Malays, however, of which there are many in the Cape, make fair artisans, though they do not generally go inland, fish being their favourite diet. In Mexico and Central and South America, the full or half-blooded Indian races supply an able-bodied and generally satisfactory class of workmen, skilled and unskilled, when led by white foremen and inspectors.

The Italian workmen are found largely in the Argentine and other South American States, and, especially those from North Italy, are splendid workers, sober, thrifty, and intelligent. They are specially good at quarry and mason work. The workmen of Northern European race in Australasia, South Africa, or Canada, are much the same as those at home, except as affected by their generally much higher wages, which sometimes induce improvidence and gambling.

Speaking generally, the black and yellow races are very temperate in their habits, comparing favourably in this respect with the white man, some of whom drink heavily when the monthly pay day enables them to do so.

In this general summary of the description of labour with which the expatriated British engineer may possibly have to deal it may be noticed that the Japanese are omitted. Until very recently, this could not have been properly done, as English engineers were frequently employed in public works there of all kinds. But not the least wonderful of the many strides forward recently made by this remarkable race is the acquisition by many of them of the peaceful art of the civil engineer, so that, practically, the European practitioner has been shut out.

Cost of Labour. Obviously, wages are dependent on the varying data of demand and supply, cost and standard of living, and quality, so that no more than a general idea of the rates prevailing can be given. To begin with the lowest. In most parts of India, the men work for 6d., and the women for 3d. a day; while in Ceylon rates are somewhat higher. The West African natives work for 7d. to 9d.; Kaffirs in South Africa for 1s. to 1s. 6d., and the half-breeds called Cape boys, whose work, language, clothes, and general standard of living approach that of the European, can earn more than double as much. The wages of Mexican and South American natives range from 1s. 6d. to 3s., while Chinamen's wages vary much according to the country in which they are working. Workmen of European birth or descent can usually earn from 4s. up to 8s. in countries abroad cool enough for the exercise of their labour. The foregoing rates are for unskilled work. The wages of artisans range from 50 per cent. to 100 per cent. more.

The economical result of work done, taking into consideration the mere constituent of manual labour, is, as a rule, much in favour of that done for the lower wage—that is to say, though less work is done for this lower wage, it is not less in the same proportion, for, as has been previously shown, the

wages are less wasted in their spending, more of the results being returned in work.

Political Systems and Trade Unionism. The privileges and restrictions resulting from these among white workers abroad are powerful influences on the conduct of engineering construction. They are practically unknown, as affecting work, among the coloured races, though Chinamen are beginning to use strikes occasionally as a means of raising wages. In Australasia these influences are perhaps more powerful than elsewhere. Arbitration courts are established in many states of the Commonwealth, the intention of which is entirely well meant, as endeavouring to prevent strikes and lock-outs, to the benefit of the employers and men, and, to some extent, this has been achieved. But, generally, the existence of these courts is not favourable to the economical construction of work.

Animal Labour. As regards the use of domestic animals in engineering construction, the only one used in the United Kingdom is the horse. Abroad, not only is the horse employed in a greater degree, but a variety of other quadrupeds are used, and as the engineer has constantly to deal with them it is necessary that their habits and uses should be fully explained. In India, the horse is used only for riding and driving, generally the former on inspection work.

The bullock, and less frequently the tamed buffalo, do all the heavy work in the south of India, while in the north, this is shared by the elephant and the camel. The great intelligence of the elephant is generally utilised in engineering practice: for instance, after a few lessons, he can be trusted, without further guidance, to carry water pipes in his trunk, and lay them end for end, the spigot of one next to the faucet of its neighbour, ready for joining, alongside of the trench for which they are intended. Elephants will also roll over large stones, and lift them into tiers, ready for setting by the masons. They are intelligent enough to understand the rights of labour, and nothing will persuade one to work after the signal is given for the dinner hour, or for knocking-off time. These animals are also used for draught, specially built large waggons being constructed for the purpose. Not only are their brain and muscular powers thus exercised, but the weight of their bodies is taken advantage of, for walking over newly-made earthwork, and consolidating it, as efficiently as by a steam roller.

Camels are also much used as beasts of burden, and it is almost incredible the amount of loading they can carry slung over the back. For instance, in the transport of merchandise, it is not unusual to load two pianos in their cases, one on each flank of one of those much-enduring animals. In Australia, horses and oxen are used for team work, and the former for riding and driving. Light four-wheeled vehicles, called buggies, are employed, sometimes with one, generally with a pair, and occasionally with four horses. Practically, there are no ponies, mules, or donkeys, to be found in Australia. A few camels, with their Afghan drivers, have been imported for service in the dry inland country.

In South Africa we find teams of horses, of mules, but more frequently of oxen, sometimes twenty-four of the latter in one waggon. The mules are mostly imported from Monte Video, and, though not so powerful as horses, are much hardier, eating fodder which a horse would refuse, and standing drought much better. They are also free from horse sickness, which is endemic at the Cape. Mules are inferior to oxen in one respect, that, when struggling with a load, they easily lose heart, where oxen, through sheer stupidity, go on putting their whole strength into their task, never thinking of any possibility of failure.

Natural Productions. These stand prominently forward when we consider the facilities or otherwise in any country for engineering construction. We find that in most of the countries with which we are dealing these are quite as plentiful as at home, and in some cases, especially as regards timber, much more so. Every description of building stone, and material for bricks and tiles, abound, and are largely made use of. A peculiar kind of stone, called *laterite*, which is unknown at home, is much used in India and Ceylon. When first extricated, it is a flaky ferruginous sandy clay, of a red colour, rather friable and soft, so that it can be easily cut into brick form, but it hardens on exposure. The extensive employment of stone and brick is more usual in the cheap labour countries, as the use of these imply considerable skilled manual work. Timber, as a substitute for these, for the contrary reason, is preferred where skilled labour is expensive, and more especially where, as in Australia, the hard woods are exceptionally strong and durable. In India, few timbers are immune from the effects of the climate and white ants, but deodar or cedar, blackwood, sâl, ironwood, satinwood, and teak, are used, and even, hard as they are, in joinery work, the cheap labour allowing much time to be spent on it. The Australian hard woods are all very close grained and heavy, weighing up to 80 lb. per cubic foot, nearly twice as much as most English species. There are hundreds of varieties, but the most known and used are ironbark, box, tallow-wood, blackbutt, red and blue gum, mahogany, and turpentine, and in Western Australia, jarrah and karri. Turpentine is proof against the Teredo Navalis, or seaworm. These are often used without seasoning of any kind, and as railway sleepers and in bridgework, have been found perfectly sound after thirty to forty years' use. Very little labour is expended on these timbers, as they are only roughly hewn to the dimensions required, for most classes of engineering construction, and, the forests being very widely distributed all over the continent, the supply is never very far from the seat of demand.

Native Timber. Australian timber is largely exported. South Africa is differently circumstanced, for the forests there are more or less isolated and, from the want of railway communication, a want which is decreasing yearly, it often pays better to import timber from the Baltic and Australia than to use the home produce. Where accessible, however, good timber is plentiful, such as yellow wood, ironwood, assegai, milkwood, sneezewood, and stinkwood. The latter, it may be said, derives its name from its pleasing odour, the prefix in Dutch not having lost, as in our allied tongue, its original agreeable sense. In West Africa the timbers are generally inferior. The Canadian timbers approximate generally to those of the northern parts of the United States, and may be said, as a rule, to be inferior in strength and durability to those of the Southern latitudes. There are great quantities of the softer woods in British Columbia, the gigantic Douglas fir being largely exported to Australia, under the name of Oregon pine, for purposes for which, from their excessive hardness, the native woods are unfit. In Mexico, and many parts of South and Central America, though there are valuable timbers, difficulty of access often leads to importation.

In hot countries, the ravages of white ants, even in very hard woods, cause great difficulty. These

insects work in large bodies, excavating galleries inside the wood, so that often their depredations are unknown till utter collapse discloses them. Creosote, corrosive sublimate, and petroleum have been used as preventives with more or less effect, but with the harder kinds of wood it is difficult, even when compressed air is used, to force the liquid into the close-grained fibres of the timber: for instance, sâl and ironwood will not absorb more than 1 lb per cubic foot. In the Australian bush wooden houses are general, and in the northern warmer parts it is common to see an inverted tin basin on the top of each of the supporting posts, above which the superstructure of the building is erected. This is to insulate the house from its supports in the earth, where the white ant originates. The posts, of course, require occasional renewing.

Stone and Iron. Gravel and broken stone for concrete and ballast are generally fairly distributed, but there are notable exceptions, such as in the coast belt of West Africa, and in alluvial deltas, where sound deposits of considerable depth occur. The absence in such places of this much required engineering material gives rise to great expense in transport from more favoured localities. Iron ore of good quality, with its neighbour, coal, to smelt it, is found extensively in India, Australia, South Africa, and Canada, but labour conditions, and often its geographical position, have presented difficulties, so that importation of manufactured steel from Europe and the United States largely predominates. Canada, however, has some important steel works. Limes and materials for cement making are much in evidence also, but isolation, the question of carriage as in the case of timber, as well as in some cases inferior quality, leads to considerable importations of Portland cement from England. This is specially the case in Australia. In Canada, however, the local manufacturer of cement has already reached a larger figure than the imports.

In many countries, more especially on the coasts, very good lime is produced from sea-shells. With regard to material generally, the immediate products of the earth, such as stone, metals, sand, etc., have their exact counterparts more or less plentifully distributed, all over the earth; but the timbers are, to a great extent, distinct in character in nearly every country.

Remoteness of Operations. Perhaps the circumstances which differentiate the duties of the civil engineer abroad from those of his co-worker at home in the greatest degree are the effects of the distances from civilised and manufacturing centres at which he has to carry on his operations. There are, of course, numerous exceptions, and many of the difficulties to which we shall have to refer will not be found if his work should lie in, or near to, the large and populous cities which now rival those at home in the provision of his wants.

In remote parts few or none of the advantages of civilisation are available. Temporary houses or tents for the engineer, his staff, and sometimes for his labourers, have to be erected and shifted as required. Provisions have to be brought, at suitable intervals, from considerable distances, according to facilities for transport: and even, not infrequently, large numbers of men have to be rationed, the business of supply being similar to that of an army in the field, while there have been instances in which clothing has had to be furnished. A doctor has probably to be specially engaged to look after the health of the camps, and if the nature of the work requires a large number of men to be stationary in one place for any considerable time special sanitary works have to be provided. Then the law has to be enforced. It is very usual in these cases to constitute the engineer a magistrate, and to give him the necessary powers and the use of constables to carry them out, as well as a temporary gaol in which delinquents can be locked up. The men have to be paid periodically, and for this a travelling pay vehicle, with an armed escort, is required to bring the necessary cash from headquarters for the monthly pay, as it would not be safe to keep a large amount of money in the camp. Frequently a special mail service has to be instituted between headquarters and the construction camp. Sometimes a temporary telegraph wire is found to be useful. Owing to the different races often employed, periodical religious services for the men are not often practical, but these are sometimes arranged for. The local engineer in charge is head of all these organisations, hence he requires more qualifications than usually suffice for the ordinary work of his profession.

Public Works Abroad. In the self-governing Colonies, such as Canada, Australasia, Cape Colony and Natal, the procedure is the same in principle, though differing considerably in detail, as that obtaining in the United Kingdom; that is to say, approval of Parliament and the Governor's assent to all considerable works is required, whether the promoters be the Government itself, or private companies, or individuals. A Bill embodying the nature of the project is presented, and if passed this becomes an Act. In India, and what are called the Crown Colonies, there being no parliament, the works, if not initiated by the Government itself, as is frequently the case, must be recommended by the Governor-General or Governor, assisted by his council, and approved by the Home Government, on the advice of the Secretary of State for India, or for the Colonies, as the case may be. The smaller provinces in India have, however, a limited power of undertaking lesser works, but the larger ones must go before the Governor-General in council.

In countries abroad not under the British flag works not undertaken directly by the State must be sanctioned by the Government, this sanction being called a concession, and generally containing stipulations as to conditions, privileges, subsidies, etc., to which we shall presently refer.

Subsidies and Land Grants. With regard to State assistance in grants of land or money. In Canada, in unsettled districts, the Government has given to the promoters of railways alternate blocks of 160 acres each, adjoining the route on either side, which the latter are able to sell, to considerable advantage, in smaller lots, after the railway is open for traffic. In the case of the Canadian Pacific Railway, the Government assistance amounted to over £5,000,000 in money and 25,000,000 acres of land. It is very evident that, important as this line has become subsequently to the world, no private company unassisted could have undertaken it, as, passing chiefly through a then uninhabited desert across a continent, no profits could have been counted on for many years after completion. Jamaica, West Australia, and other countries, have followed the same plan to some extent.

Local Assistance. Cases have occurred in the Colonies where the State, generally providing funds for public works, has hesitated in proceeding in particular cases owing to doubts as to success, and where the inhabitants of the district are so interested and confident that, without disturbing the general policy of Government construction, they have assisted the State by some of the methods

referred to, or by submitting to a local tax; but unless the assistance is by ready cash or leviable tax, security for fulfilment is very necessary.

Contract and Departmental Work. In connection with the construction of works abroad, one important variation from home practice should be mentioned. Generally in the United Kingdom, in Europe and America—Canada in this respect, as in many others, following the lead of the United States—the promoters of works, whether governments, municipalities, or companies, employ contractors. This method has in many cases abroad been abandoned, and the promoters have carried out their operations directly themselves, both by day work and small contracts, or departmentally, as it has come to be called. The relative merits of these systems we have not space to discuss, but it is necessary to state that the engineer, under the latter one, has to combine his ordinary duties with those of a contractor's agent.

Small Contracts. Whether the system be by contract or departmental, the introduction into it of small contracts, as against day work, has special advantages abroad, where superintendence is often difficult to obtain, and always costly, more of this being required when the incentive to personal exertion of piece work is absent. Though there are cases in which day work cannot be avoided, such as those involving risks which a small contractor would not take, the fact that it is the best method is well demonstrated by the knowledge that it is that usually employed by the large contractor himself. Small contracts, for labour only, have sometimes been let to workmen on the principle of what is known as a Dutch auction. In the case of the earlier South African railways, in which the workers were a medley of English navvies, Italians, Greeks, half-breeds, Kaffirs, Malays, and other nationalities, excavation of earthwork, for instance, was put up at a starting price per cubic yard, and bids offered at lower and lower rates, by different competitors, until knocked down to the lowest bidder. He would then form his gang, generally of his own race, to do the work.

A variety of the small contract method, often in practice abroad, where the intelligence of the workmen is equal to it, is that of the *butty gang*. By this a gang of men contract to do a certain work, and when finished, the engineer, or overseer, divides equally among them the money due on the measurement.

The Profession Abroad. Not many years ago, the countries to which this course more particularly refers had to rely on the United Kingdom for the civil engineers they required; but gradually, and indeed properly, the Colonies and other places have become, comparatively speaking, well supplied, not only by such men who have, after the expiration of their agreements, decided to remain in the country, but by others who have gone out voluntarily to try their chances. These, with their Colonial pupils and others trained at local universities, since established, have rendered many lands self-contained in this respect. Moreover, there is actually a tendency, in a few states, to frame regulations for the practice of the profession, which throw difficulties in the way of strangers engaging in it at all.

In India, Australasia, South and West Africa—and, to a small extent, in North and South America—so many of the public works are carried out by the Government that a large proportion of the engineers are practically, and in some cases actually, members of the Civil Service, entering on their employment by regulated tests or examinations, acquiring pension rights, etc. In such countries, of course, the field for the engineer in what is there called private practice is very limited. For example, in one of the principal states of the Australian Commonwealth over 75 per cent. of the civil engineers are in Government employment, and in such cases the remainder have often to eke out a sufficient livelihood by combining their calling with that of architect, or land surveyor, or both. Contractors, in all countries, are frequent employers of engineers. The system of apprenticeship is not so general as it used to be, the more usual plan of entry into the profession abroad being through local university training; but not infrequently, irregular methods of becoming a professional civil engineer are tolerated, such, for instance, as promotion from the position of a draughtsman or inspector, to the higher status, with or without an examination.

In India there are universities, with affiliated engineering colleges at Calcutta, Madras, Bombay, Allahabad, and Lahore, on the model of the London University, besides two colleges for civil engineers. These, however, are primarily meant for the natives of the country, among whom there are already a considerable number of trained and capable men, many being corporate members of the Institution of Civil Engineers. In the capitals of all the greater Colonies there are also efficient universities, with engineering schools and laboratories, and there are usually in such cities also engineering societies, composed of the practising members of the profession, where papers are read and discussed.

Qualifications of an Engineer Abroad. Abroad, it is more than ever necessary for the engineer to remember the old adage, that an ounce of practice is worth a ton of theory. Certainly, a different set of qualifications, both physical and moral, is required from that which is sufficient for home work. As hardships are more likely and, in a few cases, worse climates may be encountered, a better physique and sounder health are necessary. Greater resourcefulness also is wanted in the engineer, as he has not the same means to his hand for his requirements, and he has probably, owing to distance, not equal opportunities of consultation in difficulties with his superior officer. Should survey work be engaged upon, the following acquirements, which, for the most part, will be gained locally, are a great help: First, a sense of locality—a great gift in far-away lands, what is called in Australia being a good bushman—that is, being a close but almost unconscious observer of physical features, such as the position of the sun and stars, the growth of moss on the weather side of trees, and countless indications which may guide him who has lost his way, far from help, in the trackless forest. Then, a knowledge of horses with their points and ailments, of riding, shooting, fishing, rowing, cooking, use of tools, tent-mending, and rough surgery—all these help the surveyor in camp. If the engineer's lot should be cast in countries outside the English-speaking Colonies, the acquisition of native languages may be necessary, and is always desirable, but this may well be left till his arrival on the spot.

In the United Kingdom there exists an elaborate ordnance survey in considerable detail. Therefore, the operations necessary to make it serve for a map or plan, on which the proposed work may be drawn, and from which it may be marked out, are not considerable in extent [see CIVIL ENGINEERING, page 1145]. In many cases, little more is

required than to measure up fences, houses, etc., which have been added since the date of the ordnance survey, or to enlarge at points where special works require more detail. There are, of course, in India, and some of the Colonies, small scale Government surveys, but these are generally insufficient, except for what is called preliminary or trial work.

Primeval Conditions. But there may be regions to be dealt with which do not possess maps even of any kind, however small, and of which the geography has to be virtually discovered by the surveyor. Explorations, followed by rough reconnaissance surveys, totally unnecessary and unknown in home operations, are indispensable preliminaries, and, owing to dense forests, he may have to adopt as his base line some trade route, possibly only a bridle path, which, though wanting in directness, may be the only feasible one without the great delay of cutting his way through in a more direct line.

Surveying by Photography. Reconnaissance surveys by means of photography are common in both North and South America. This is a system which it would require a textbook to explain, and therefore it cannot be more than referred to here. "Photographic Surveying," by E. Deville, published in Ottawa in 1895, is a good work on the subject. Sufficient it is for us to say that the system consists in the determination of the position of any objects as to their distance, elevation, and direction, in relation to the observer, by means of the calculated proportions which exist between the apparent perspective distances, etc., as either traced on a vertical glass, through which the observer sees them, or as received on a photographic plate, and the true dimensions [see page 595]. The system is sometimes preferred to the use of the plane table [see page 710], as the field work consists of observing only, the plotting being done in the office, thus saving some of the wages of the chainmen. It is often called "Photogrammetry," and by other similar names, but Deville prefers "Iconometry," as though photography affords the most convenient means of doing the work, it is not the essence of it.

Location. Coming to the second part of the engineering surveyor's work, that of location or designing, and marking on the ground the position of the proposed work, the latter merely a mechanical operation, differs only in minor respects from that required under home conditions [see page 801], but the circumstances governing the choice of location, or design, are very different in each case. For example, in laying out a road, railway, canal, or pipe line, the home engineer is almost as much concerned with minimum interference with private property as he is with topographical features, and his best result is obtained when a judicious mean is attained, varying towards the one object or the other, according to the value of the property and the extent of the physical difficulty before him. Abroad, except close to large cities, the property consideration is as nothing, and, practically, the whole attention is concentrated in avoiding or dealing with natural obstructions.

Location of Townships. In new countries it not infrequently happens that an engineering work, more especially a railway or a road, precedes settlement, unlike such undertakings in the older lands, which are never projected except between places already settled and populated to some extent, though, of course, an increase may be looked for due to the improved communication.

Not so always in the Colonies. In some cases, therefore, of a projected road or railway, towns and villages will not have come into being, even on paper, in a district be it ever so fertile. In these cases it often falls to the lot of the engineer to fix sites for future towns which will not only be suitable, as regards water supply, drainage, foundations, etc., but also conformable to the project with which he is more immediately concerned.

Resources of the Country. Then in the newer lands the facilities for the construction of any proposed work are often little known beforehand, and the surveyor is consequently called upon in that case to furnish a report on the resources of the district as to stone, timber, gravel, material for bricks and lime, water supply, etc., and even sometimes as to the fertility of the soil and mineral productiveness, with the view of informing those who have to decide as to the desirability of the proposal. So it will be seen that in order to judge rightly in these matters, quite an additional number of qualifications to that necessary for the home practitioner is required.

Surveying Instruments. As to instruments, the surveyor will find abroad a tendency, unless when special accuracy is required, to the use of light ones, more especially where labour is dear—in fact, he will probably often have to carry some of them himself. It is not uncommon, for instance, to meet in Australia the surveyor riding at a rapid pace through the bush with a theodolite set upon its legs and carried on the rider's shoulders. For the same reason there is a tendency to do, if possible, by a theodolite the work ordinarily performed by means of a spirit level, so as to combine two different operations with the one instrument. Various forms of tacheometers have been devised, partly with the same end in view, though the weight of this instrument is an objection [see page 710]. The plane table [see page 710] is much used for the preliminary survey which is such a prominent feature of our course, and the ordinary miner's dial has been found very useful in the dense tropical forest of West Africa, and is preferred there to the prismatic compass [see page 267]. The instruments used in iconometry are various, both for use in the field and for plotting, such as the photo theodolite, the photometer, the diagraph, the perspectograph, the centro-linead, and the perspectometer.

As regards the later and more detailed surveys, the instruments used abroad are generally similar to those at home, but steel bands, instead of the ordinary link chain, are almost universally employed, as less likely to catch in undergrowth, etc. In countries where the metrical system prevails, the chain is 20 metres long, which is about 4¾ in. shorter than the English 66-ft. chain. The levelling staff is also divided into metres and centimetres. A feature in the marking of the position of proposed works in new countries is the necessity of making marks for this purpose very substantial and permanent, and to number them, for, owing to the absence of artificial features, such as fences, etc., it would be otherwise difficult to find them again when the construction engineer comes on the ground.

CIVIL ENGINEERING *concluded*

PRINTING FROM STONE

The Craft and Trade of Lithography. The Cumbrous Stone and its Metal Substitutes. Lithographic Inks. Colour Printing. Rotary Printing

LITHOGRAPHY
Continued from page 6486

By CHARLES HARRAP

LITHOGRAPHY as a business or craft is but young compared with the majority of trades, as its discovery by Alois Senefelder dates back only to 1798. It still appears but a new art to many of the older workers and to those who have intimately investigated its early stages and its early specimens.

As a craft it is one attended with so many difficulties and so many "discoveries" that it is rendered at once pleasant, as well as intricate, to all who may be engaged therein. Not only do these trying circumstances surround the man who has learnt the trade, but they come upon the amateur or novice in the way of surprises which, for some years, are very trying, not to say disheartening. The toils of the trade are not rendered any easier by the traditions which have been handed down through three or four generations of workers who learnt originally only how to work by inspection and under special guidance, without ever attempting to learn why particular methods were adopted. This has proved not only a barrier to progress, but has been the cause of preserving the use of methods and materials which ought to have been discarded at an early date—yet it is these very antiquated notions which are held in such respect by the old-fashioned craftsman.

The Trade of Lithography. From its inception as a business in London about 1818, the trade has been gradually on the increase, and at the present time no less than 10,000 craftsmen are directly employed in the production of lithographic prints in Great Britain alone. But although the trade is a small one, it has probably given greater pleasure to a larger number of persons than any other craft, large or small. It has been the means of preserving the works of excellent artists in a beautiful and lasting form, and this has been accomplished at a minimum of cost.

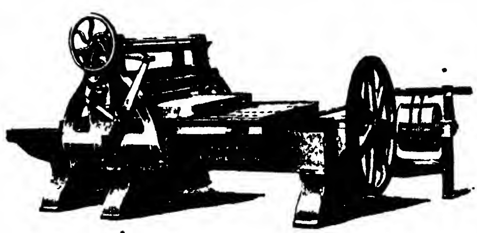
Lithography is responsible for the production of many pictures, as posters and showcards, which have given great pleasure to the whole people, and have assisted in illuminating the dark corners of our streets and otherwise unsightly hoardings. The many ways in which lithography has been brought to bear upon other printing crafts has done much to increase the production and lessen the cost of such arts as engraving and photography. As an illustrative art it has been so often and so successfully called into requisition as to make it practically indispensable to all good publications. Of course, it has had its trials, and it was many years before it ousted such processes as aquatint and mezzotint, as well as much copper and steel plate engraving, from their premier positions.

In the early days of the art it attracted some of the best artists or sketchers as a means of actually producing their own work directly upon the stone; and one artist, R. J. Lane, became an Associate of the Royal Academy through his superb productions from sketches and original productions directly upon stone.

What Lithography is. Lithography is, as its derivation implies, writing or drawing upon stone. But it has the further meaning of producing copies or prints from a stone. More recently the trade of lithography has been construed to include both printing from zinc (*zincography*) and from aluminium (*aluminography*). If a generic term can be applied, the whole of the different methods should be termed planography, as they are all, virtually, methods of printing from a flat surface or plane. The expression flat surface must be further defined as polished surface, or a grained surface, in contradistinction to a surface etched in high relief. The use of zinc as a printing surface was very little posterior to stone, but aluminium cannot be placed prior to 1890.

All three methods are generally practised by the lithographic printer; and not a few printers are also able to work the various photographic processes akin to, and including, photo-lithography and collotype. So numerous are the methods employed that a lithographic printer has at his command the means of producing any print from the roughest draft plan or specification of the architect to the finest form of imitation photograph, in black or colour. The photographic processes now applicable to lithography are so far advanced that three-colour work is practically within its available bounds.

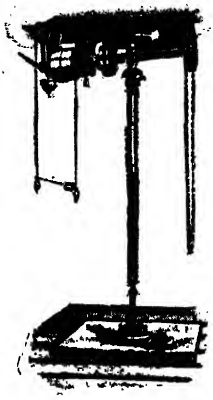
Lithographic Stones. The stone used in lithography is an exceedingly fine, close-grained chalk or marble, geologically known as a "slate," the latter term having been applied because of the form in which it exists in quarries. These quarries are largely developed around Solenhofen, and extend many miles. But a formation of similar stone runs from Bavaria northwards into Norway and Sweden, and southwards through Switzerland, France, Italy, Spain, across by Corsica and Sardinia, into North Africa.



1. STONE-PLANING MACHINE

Formations of the same rock are known in Turkey (around Salonica), Greece, Asia Minor, and the Caucasus mountains, and stones from all these districts have been actually used. A firm in Greece has printed largely from Greek stones; another firm in Berlin has used Caucasian stone; samples from Turkey and Asia Minor have been used in England; and Spanish stone is largely used in Barcelona. French stones have had considerable patronage, but German stones are, without doubt, the finest products, and are used throughout the world; and it is estimated that in a not far distant future the supply will be exhausted. It is this fact, coupled with the cost and weight of stones, which has caused the

introduction of metal plate substitutes, and a strong attempt to compound a stone of similar qualities. The efforts in this direction have been many during the last fifty years; but the want of knowledge of the actual composition of the stone, and the inability to apply the forces which originally compressed this fine chalky mud into a durable rock, have so far been a barrier to its accomplishment.



2. STONE GRINDING AND POLISHING MACHINE

Artificial Stones. At present, many forms of stone are successfully copied artificially, and it seems more than probable that if artificial production should be successful in the lithographic trade, it will prove doubly beneficial, for at the Bavarian quarries the appearance of the country is disfigured by the enormous mounds—even hills—of stone-quarrying debris, which could be used, and a cheaper article put upon the market. At the present time (1907) a firm successfully manufacturing marble (exhibited at the Building Trades' Exhibition, 1907) is progressing with the manufacture of lithographic stone.

3. ADVANCE LITHO PRINTING MACHINE

The statement that failure in making artificial stone may be due to a want of knowledge of the constituents of lithographic slate is perhaps open to criticism. The composition is broadly that of marble, with a little something else which makes the difference—a small difference, but an important one. The original geological formation was probably in progress some hundreds of thousands of years, and the gradual consolidation of the rock was attended by such circumstances in watery surroundings, the juxtaposition of various chemicals and a heavy pressure, that the result is a stone varying in its character just so much—yet very little—from marble, that while the latter is quite useless, the lithographic slate is the only article that can be used. Like marble and chalk, it undoubtedly owes its origin to immeasurable quantities of fine shells—shells pulverised to an imponderable dust—and ultimately deposited in marine waters as a mud, to be converted finally into stone.

The Chemistry of Lithography. The actual processes of lithography, zincography, and aluminography, are dependent upon chemical actions. In pursuing these methods, the chemistry of each must always be the actuator of the printer, for the same chemicals may not be used to attain the same object in each case.

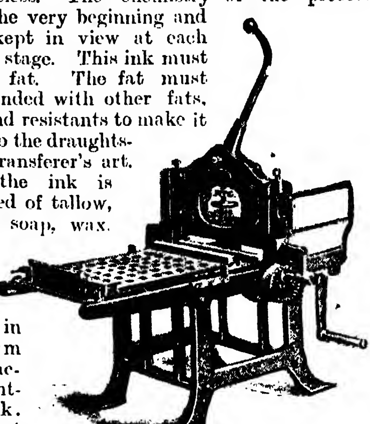
The objects of the chemicals used may be set forth as (1) rendering the surface non-sensitive to grease; (2) rendering the surface sensitive to grease; (3) rendering the work invulnerable to decomposition by acid; (4) rendering the work easily removable by acid; (5) attacking the constituents of the ink used in drawing to make them combine with the printing surface; (6) compounding the original drawing and transferring inks; and (7) compounding the printing inks.

The foregoing brief survey naturally leads directly to a closer description of lithography in detail. In dealing with the subject, little will be said of zincography and aluminography, except by briefly mentioning some of the variations of treatment.

Preparation of the Stone. To obtain an original upon a stone, the stone must be ground down to a slab of equal thickness, so that both surfaces are parallel; then one surface must be ground perfectly level to receive the work. This is accomplished by grinding with sand, by the more remote hand methods, the more recent mechanical appliances [2], or by the latest device of planing the surface in a machine constructed with a long steel planing blade [1]. This machine may be said to be the most perfect appliance yet introduced for the purpose, as it can be gauged to plane off an extremely thin layer of stone, leaving a perfectly level surface all over.

After grinding or planing, the surface is burnished with a close-grained slate, until it presents a distinct semi-glassy polish, without scratches. Upon this surface, when dry, original work may be drawn or transferred, providing the subject is executed in a line or dot. If the work is of a "grained" character, the polished stone must be suitably grained by sprinkling with fine sifted sand, and rubbing the sand evenly into the stone all over, until the surface is broken up into a fine grain. The sand is then washed off, and the work drawn upon the dry stone with specially prepared ink, called crayons.

The Inks of Lithography. By whatever method the original work is put upon a stone the ink used must contain certain standard articles or it is useless. The chemistry of the process starts at the very beginning and must be kept in view at each succeeding stage. This ink must contain a fat. The fat must be compounded with other fats, solvents, and resistants to make it amenable to the draughtsman's or transferer's art. Generally the ink is compounded of tallow, palm oil, soap, wax, stearin, shellac, bitumen, and a diluent in the form of manufactured printing ink. These are not all used in one ink.



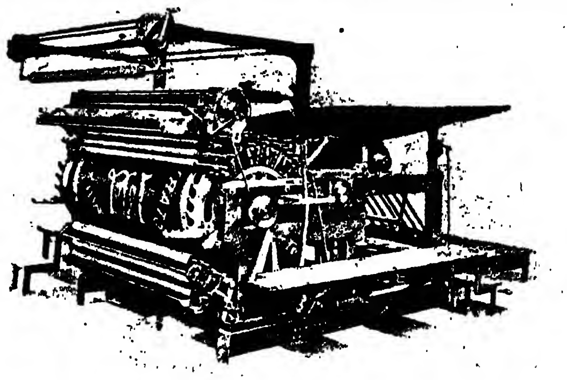
4. MODERN GERMAN HAND-PRESS

Thus, the draughtsman's ink may contain tallow, wax, soap, shellac and printing ink; the stone transferring ink, tallow, stearin, palm oil, soap, and printing ink; and the copperplate transferrer's

ink may be somewhat similar to the last with bitumen or asphalt. Crayons may contain only tallow, soap, wax, and shellac. Photo-lithographic transfer ink may be similar to plate transferrer's ink without soap. The variety of the lacs is subject to variation to meet the needs of greater or less hardness, or necessity for etching. The object to be attained is to bring into contact with the stone some form of free fatty acid. It is common knowledge that chalk—lithographic stone—when treated with an acid suffers decomposition and some compound is the result. This is especially the case when a fatty acid attacks the stone, as the resulting compound is an insoluble salt of the calcium of the stone with the fatty acid of the ink. This compound is the real printing "surface" procured upon the stone. Similarly, fatty acids (as well as many other acids) attack zinc and aluminium, and in these cases produce an insoluble compound which gives the printing "surface."

Etching the Stone. The work having been drawn or transferred upon the stone, the printer proceeds to obtain impressions. If the work consist of heavy masses of thick ink it must be "etched" or treated with an acid that will decompose the surplus soap in the ink and convert it into an insoluble compound with the stone. This is especially necessary with work drawn in crayon upon grained stone. The etch may be a watery solution of nitric acid, or tannic acid, or weak tea; or a mixture of gum arabic solution and nitric acid.

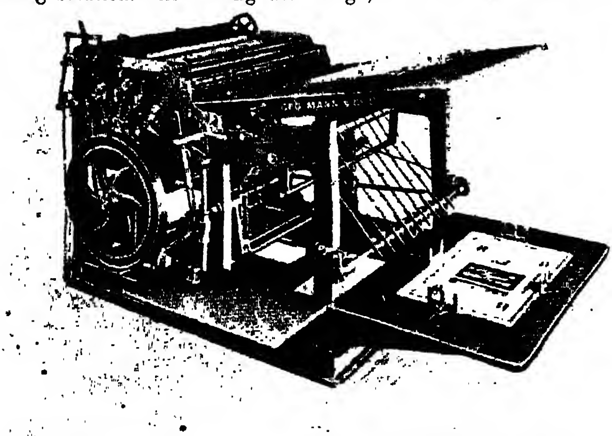
The older method of etching grained stones was with a very dilute solution of nitric acid in water, and it was applied in two ways. The first was to pour over, or deluge the stone with a large jug full of the etch, the whole of it running off the stone into a jug and being used again. The second was to place the stone in a rocking-trough, and fill the trough to the top edge of the stone with the etching solution. In rocking the trough, a wave of etch passed evenly over the stone and left it clear. Both these methods have the pre-eminent advantage of leaving the stone free after immersion, thus allowing the heavy bubbles of gas to escape from the surface before a second etch is commenced. In either case, the applications of the etch are numerous before it is completed, and its completion is so much a matter of experience that no rules can be given. This phase of the subject is dealt with apparently in greater detail than it warrants; but it is so important in its bearings that both the principle and methods involved might be applied usefully to some present-day practices.



5. LINOTYPE LITHO ROTARY PRESS

This treatment having been performed, the actual work on the stone is in a more or less insoluble condition in hot or cold water, and is strengthened by the etch. The work may then be carefully inked, either by dabbing or rubbing printing ink on it with a fine soft rag, or by rolling up with ink on a leather roller; in any case gummy water must be kept on the stone to preserve uniform dampness and to prevent the particles of the original ink from catching upon the surface of the stone and forming a scum upon its surface. Having charged the work with ink the stone may be washed clean.

Preparing for Printing. If the work be not drawn, or transferred, in heavy thick masses, the first etching may be dispensed with. Such treatment also applies to work put on the stone in a hard or bituminous ink which has not had time, or does not contain sufficient active agents, to cause its ready combination with the stone, and does not require an etch. After charging with ink and washing clean, the work cannot be considered in quite such a strong condition as necessary, and it should be covered with a fine resisting powder, such as resin, talc, or silica, when it may be lightly "etched" with dilute nitric acid. The acid actually decomposes any remaining soap in the ink, as well as the actual stone, thereby carrying away many loose particles of grease which have been carried accidentally on to the surface of the stone. The stone is again washed, and well covered with gum arabic. This gum is of a complex composition, and there is little doubt that it forms a surface on the stone



6. METAL-PLATE ROTARY LITHO PRINTING MACHINE

impenetrable to grease. Finally, after the gum has dried, it may be washed off; the work is then "cleaned" or washed out with turpentine prior to final rolling up. It is then thoroughly cleaned up by using a scraper of steel, a wooden stump with acid, or a fine stick of polishing stone prior to printing the copies from the stone.

Printing Machinery. The printing is usually done in a machine which is fitted with damping rollers and leather inking rollers to imitate the hand press method of damping a stone well [4]. Printing is seldom done from the original drawings. Transfers are taken from the originals and put upon new stones, so as to preserve the originals for further use. The originals themselves may be transferred to zinc or aluminium plates and stored away, thus liberating the expensive stone. Wherever possible, the originals should be drawn on the plates. The impression is procured upon paper which is carried on to the surface of the stone upon a cylinder—the cylinder being forced down upon a stone by powerful springs or weights. The action of the machine is to take the stone under damping rollers, which moisten the surface of the stone to prevent greasy ink catching; thence under the series of inking rollers. The stone returns under the inking rollers, getting fed a second time, and in completing its backward journey the printing paper is brought down upon its surface. The contact of the paper with the stone is reduced to the fine line made by a perfect cylinder coming in contact with the flat surface of the stone, the whole pressure of the powerful weights or springs being brought to bear upon this rapidly moving line of contact [3].

The latest idea in lithographic (planographic) printing machinery embodies the possible culmination in the art of printing from a flat surface. In the past it has been the common practice to print upon paper by direct contact of the hard surfaces of the cylinder and the stone or metal plate. This practice has had its variations in the Orloff method as applied to printing on paper, printing on tin, and collotype printing, where the printing surface is soft. But this principle has been applied to lithographic printing upon paper in the well-known lithographic machine of the rotary type [5]. The success of such method has been proved upon hard and rough paper by printing from an intermediate soft transfer appliance, as introduced in 1907 by G. Mann & Co., of Leeds, under their patent of 1903 [6].

Lithographs in Colour. The feature of lithography which, perhaps, to the general public is the most interesting, is the production of coloured prints—chromolithographs—upon paper, card, earthenware, silk, satin, etc. The process is difficult owing to the great care which is necessary in every detail. An oil painting is reproduced in the following way. A tracing is taken from the picture. This tracing is generally made upon a thin sheet of gelatin, the actual tracing being done by "cutting" in the gelatin with a fine steel point. This copy takes not only the general outline of the subject but includes the boundaries and contours of all the various colours and mixtures of colours. This *engraving* on the gelatin is then filled in with transfer ink, carefully cleaned, damped (in a special damping book), and laid down upon a perfectly clean stone. It is run through the press and transferred to the stone, to be gummed up and rolled up as ordinary work. It then constitutes the *key* or guide. From it a number of impressions are taken upon a hard-faced paper or paper mounted on zinc, so that there will be one impression for each colour that the artist intends to use. These impressions are dusted with an offset powder, of common red chalk, or aniline, magnesia, and carbolic acid. The latter is the best as when put upon the stone it penetrates, and the stone may be washed and polished lightly without removing it.

These dusted impressions are run down upon separate clean stones, and then constitute the offsets, to which the artist draws all the colours in the proper lithographic ink. When complete they are all rolled up in the ordinary way, and the impressions in each colour are pulled, one by one, on top of each other until the whole picture is finished. The process requires great care in getting each colour to print in its correct place—*registering*; and in the use of colours which, by overlapping one another, give the correct colour scheme of the original.

Transfer Processes. In the preparation of originals, the stone, zinc, or aluminium is not employed for drawing directly upon entirely. Many originals are executed upon transfer paper. The paper is prepared with a gelatinous surface compounded with an inert dust. Transfers may be taken from copper plates, steel plates, stones, or type, and patched up into the necessary design, when they are transferred to stone.

A branch of the transfer process prepares originals direct from photographic negatives in line, dot, or stipple. It is applicable to producing certain kinds of originals direct upon aluminium, zinc and even stone. It is applied to producing work by the colloytpe, photo-stone and photo-lithographic processes, little used prior to the past ten years [see pages 6483 and 6486].

Transfers are used in all cases where a large number of prints are produced at the same time.

Substitutes for the Cumbersome Stone. Both zinc and aluminium have been adopted, more extensively in recent years, chiefly owing to their adaptability to be "mounted" upon cylinders, in rotary machines, which have been much improved in the past ten years.

The same reagents will not suit all surfaces. Nitric acid is the acid par excellence for the general treatment of stone; it is positively inert upon aluminium for similar purposes, and on zinc its effect is not beneficial. Oxalic acid has particular uses upon stone, which are opposed to its effect on aluminium. Caustic soda, little used upon stone, is a solvent of aluminium, and on zinc is distinctly useful. Phosphoric acid is scarcely used upon stone, whilst with zinc it is of prime importance. Much more could be written on the differences between the treatment of these surfaces.

The applications of planographic printing are both beautiful and numerous. The well-known oleographs, the ever delightful Christmas cards, the illustrated toy books, and the host of atlases, natural history books, and artistic publications, owe their value and their charm to this business—a business which is not an amateur one, which is not of an ephemeral character, but one in which success can be attained only by many years of steady application.

Three good books on the subject are "Practical Lithography," by A. Seymour (1903, Scott, Greenwood & Co.), "Handbook of Lithography," by David Cumming (1904, A. & C. Black), and the "Grammar of Lithography," by V. D. Richmond (E. Menken).

Continued

SYSTEM IN THE FACTORY

Factory Organisation. Records of Cost and Labour.
Time Recorders and Other Labour-saving Appliances

Continued from page 6522

By D. N. DUNLOP

THE revolution in business methods which is silently taking place is nowhere more apparent than in the factory. New processes, the invention of new tools, new methods of gearing them and increasing their efficiency, the use of new combinations of cutting steel, have not only caused radical changes in factory practice, but also in the character and skill of the labour employed.

Industrial organisation has become a new science. The authorities and executive required by a factory organised on up-to-date lines are shown in the table below.

The Complete Factory System. A complete factory system comprises three main divisions:

(*a*) The system of cost accounting and record keeping.

(*b*) A system controlling the procedure by which raw material is converted into a finished product, including records of all kinds of labour and of machinery.

(*c*) A system for keeping accurate records of raw material and finished product received or produced, requisitioned and on hand.

To be effectual the cost system must at least perform the following functions:

1. It must furnish records of the work and relative efficiency of workmen and foremen, as well as of machines and departments.

2. It must act as a diagram for the organisation of the whole factory which it holds together.

ORGANISATION OF A FACTORY—AUTHORITY AND EXECUTIVE

DIRECTOR

EXECUTIVE COMMITTEE—{President. Treasurer. Vice President. Secretary.

AUDITOR

ADVISORY COMMITTEE — CHAIRMAN — GENERAL MANAGER

FACTORY — OFFICE

DEPARTMENTS.		DEPARTMENTS.	
MECHANICAL ENGINEERING ..	*Mechanical Engineer:* power, plumbing, testing, equipment.	BUSINESS MANAGER AND ASSISTANT	Sales, advertisements, collections, purchases, costs, estimates, audits.
STORES AND STOCK	*Chief Storekeeper:* production orders, all material, requisitions, perpetual inventory, shipping requisitions, finished product, tools.	ACCOUNTING	Bookkeeping, pay-rolls, sales, collections, billing, costs, cash, disbursements.
RECEIVING ROOM	*Receiving Clerk* unpacking, checking receipts, purchase and requisition.	CORRESPONDENCE	Letter writing, mailing, postage, telegraph and telephone, contract writing, filing of office documents.
DRAWING ROOM	*Chief Draughtsman:* drafting for products, outside contracts, equipment.	SALES DEPARTMENT	Salesmen, agents, dealers, regular products, parts and repairs, outside work.
PATTERN ROOM	*Foreman:* pattern making, carpenter work, pattern stores, requisitions.	PUBLICITY	*Manager:* advertisement writers, translators, researchers, photographers, engravers, artists, catalogues, circulars, pamphlets, press work, printing.
TOOL ROOM	*Foreman:* all tools made for own use, and outside work.	PURCHASE	Material, supplies, office stores, tools, machinery.
SHIPPING ROOM	*Shipping Clerk, Warehouse Clerk* packing, shipping, transport, checking invoices, shipping documents.	ORDERS	*Order Clerk:* regular product, repairs, parts, outside work.
SUPERINTENDENT'S OFFICE ..	*Superintendent:* manufacturing inspection, tracking orders, all requisitions, auditing, maintenance, outside expense, shipping.		

N.B.—The chief authorities are given in italics.

3. It must enable the superintendent to follow the work through each department of the factory, to detect defects and provide remedies.

4. By means of a system of receipts and requisitions, it ensures that everything used or produced in the factory shall be accounted for, and responsibility for all defects and losses located.

5. It keeps watch on the output per man, per machine, per department, and for the whole factory, giving danger signals when the ratio of costs to output oversteps safe limits.

6. It furnishes the means of securing comparisons on all manufactured products as well as data for a close analysis of the comparative costs of jobs at different periods; and of estimated costs, tenders, and contracts.

Systems of Cost Keeping. The cost department of a factory under a chief accountant or cost-keeper takes cognizance of the important factors of *material*, *labour*, *factory burden* (*manufacturing expense*), *general expense*, including depreciation, and *special items of cost*. It deals with them in harmony with the other systems of organisation.

It is necessary to keep three sets of costs for every product manufactured.

1. The *flat cost* or *prime cost*, including the price of raw material or stock parts, and the cost of the productive labour.

2. The *factory cost*, comprising the prime cost, plus the *factory burden*—that is, factory non-productive labour, manufacturing supplies, and any other expenses incurred by the factory directly.

3. The *total* or *selling cost*, consisting of the factory cost, plus the proper percentage of the general expenses chargeable to the order, for items such as interest on capital, insurance, depreciation, salaries, rent, taxes, maintenance, etc.

The organisation of a cost department necessitates only a small addition to the staff—namely, the cost-keeper or factory accountant, and perhaps one or more clerks, according to the magnitude of the business, and a few for the card-filing cabinets.

Routine of the System. The prime functions of this system have already been discussed. The system ensures that none but written orders, duly signed, take effect in any department, and that clerical work is eliminated as much as possible from the shops. Work is set going in the cost department by the issuing of a production order signed by the general manager, which concerns the whole establishment. The general manager's clerk then makes out the factory order in duplicate, giving it a number which must be recorded on every card, loose-leaf, or voucher concerning it, and accompanies the work on its progress through the shops; the order bears particulars as to estimate, tender, correspondence, and customer, which enable the whole history of its genesis to be kept on record.

The factory order passes on to the superintendent, who files it after making out a separate production order for each department concerned. If the order be for a new type of machine, the superintendent sends written instructions to the drawing office, where the necessary drawings are put together.

Working lists are then drawn up for the foremen, giving them detailed instructions concerning every operation, even the most trivial, which is to be performed in their shops; the duplicates of the working lists are filed in manilla folders for reference; they contain an additional column for the cost of each item to be added on completion of the order.

In the Stockroom. Each foreman on receipt of the production order and working lists sends a requisition card, prepared for him in the cost department, after duly signing it, to the storekeeper for the raw material or stock parts necessary for the operations in his shop.

The stock-keeper, on issuing the material, returns the card to the foreman and registers the disbursement in the card index of his perpetual inventory, fills in a material disbursement card, which he forwards to the cost department. The cost of the material may be filled in by the stock-keeper, but the better plan is to keep all records of costs in the cost and record departments, and to leave that item to the cost-keeper to fill in.

The amount is charged to the shop in question, and the card remains on file with other disbursement cards for the same order, until the labour cards come in from the departments concerned and furnish the data necessary for compiling the three sets of costs mentioned above. The disbursement cards act as signals to the stock-tracer, who may be one of the inspectors, and whose duty it is to follow the progress of each order, step by step, through the shops, deriving his clues from the various cards which come in to the cost department. The stock tracer's records take the form of transfer cards, recording the factory order number, the date, the departments between which the transfer takes place, the number of pieces, the number passed, the cause of rejection, the name of the part and symbol or number, the machine on which it is used, the storage record (section, bin, shelf, or rack), the requisition order number, remarks, and the signature of foreman.

Progress Through the Shops. Meanwhile, the production order proceeds through the shops. The foreman is furnished with job cards, one for each job, ruled and filled in as far as possible, in the cost department, leaving him the date, name of workman, and signature to add. The cards are prepared in advance so that no time is lost between jobs. The workman registers the time at which he starts a job on a mechanical recorder, and when the work has been examined by the foreman he registers the time in the "finished" column of his card, receiving at the same time the card for the next job, which he at once registers in start column. The foreman signs the card for the finished job, and forwards it to the cost department; but he keeps the production order and material requisition card until the order is completed. As the cards come in daily—one might say hourly—from the various departments, including painting, assembling, testing, packing, shipping, the cards belonging to the same order are filed together, and the detailed total-cost card is made out from them, a duplicate being sent to the commercial office for the use of the bookkeeper, who charges the amounts to their proper accounts in the loose-leaf ledgers.

Orders for repairs are treated in exactly the same manner; the number assigned is, however, in that case preceded by R for outside work, and by MR (maintenance repairs) for repairs to the plant.

The Record Office. The functions of the record office, which may at first sight appear to be unnecessary, are really of the greatest importance in modern industry. At first these may be undertaken by the cost department, but as the utility of the records becomes appreciated, and fresh series of records suggest themselves, then the need for a separate department asserts itself. The cost department furnishes the data; the record office makes use of them to compile deductions, statements of efficiency and of progress. An efficient record office has the power to secure the reduction of the cost of production to the lowest minimum,

and, by a thorough system of supervision and control, to eliminate waste.

The Distribution of Manufacturing and General Expense. Manufacturing expense, or the factory burden and general expense, affect respectively the factory and the selling cost. It is evident that, to be profitable, manufacturing must include selling the output at a definite profit on the entire cost; the difference between the selling or total cost and the selling price must, in fact, be pure profit. We have seen how a modern department arrives at the prime cost by means of a simple and direct system. The computation of factory and selling costs, which are no less important, is generally considered to be a matter of great complexity and difficulty. This is undeniably the case in a factory deficient in organisation and without an up-to-date cost system. The result is that the task is often shirked, and a percentage is estimated to represent expenses, which is often wide of the mark, and entails heavy losses.

The Factory Burden. The chief items of factory expense are interest on capital, rent, taxes, insurance on buildings and machines, depreciation and maintenance of equipment, power, lighting, heating per area of floor-space, supervision, salaries, general unproductive labour, supplies, etc.

Approximate expenses should on no account be charged equally to all jobs passing through the shops, excepting those expenses which, from their very nature, cannot be connected with any operation. It is obvious that in large machine shops, for instance, each machine or group of machines involves a certain running expenditure per hour, such as power, attendance, depreciation, maintenance, supplies. *These expenses are all proportional to the time the machine is running,* and cease when it is at rest. The other items of expense are fixed, and never vary.

The Machine Rate. All the expenses which should be borne by each individual machine must be carefully computed and charged by means of an hourly rate to the job for which the machine has been used. In order to accomplish this, it is necessary to take the following steps:

1. The items composing the machine rate must be figured out.
2. A schedule of classification for all machines used must be made, as explained in the section on the applications of the card system.
3. The workman's job card should be ruled to include columns for the hours during which the machine has been operated, for its number, and for the hourly rate.

In order to deal fairly with the two different classes of charges, the fixed expenses, which are constant for the year, divided by the number of hours the machine has worked, form the *machine rate.* Those expenses which vary with the conditions of commercial and shop efficiency are thrown into a *supplemental* or *variable* rate, computed weekly and charged equally to all jobs passing through the shops. A card-index is used for the schedule of classification for the machines, a separate card being allotted to each individual machine, showing its number, cost, interest, insurance, depreciation, rent, taxes, floor-space, and the machine rate as soon as it has been figured out.

Example of Machine Rate. The following is an example of the application of the system: The rate for a machine, No. 312, costing £600, might be approximately as in the following table.

	£	s.	d.
Interest on capital at 5 per cent.	30	0	0
Depreciation	60	0	0
Insurance	50	0	0
Floor Burden (rent and taxes per square foot of floor space)	140	0	0
Power	60	0	0
Share of general supervision	10	0	0
Waste-oil and belting, etc.	30	0	0
	£380	0	0

On account of machine No. 312, £380÷2,400 hours worked during the year=3s. 2d. hourly machine rate for the year.

The supplemental or variable rate is computed thus: The same items given above per machine *are debited in the aggregate per shop* for the week, each shop being credited with the total machine rate charge for all machines for the week, collected from the weekly summaries of job cards. The balance is divided by the total hours worked during the week by all machines in that shop, which gives the supplemental rate per hour, to be charged to each job over and above the hourly rate, according to the number of hours' work put into the job.

Supplemental Rate. This system is easily put into practice, as in the following example:

Labour costs of order No. 617, Dept. IV.:

CASE A.

	£	s.	d.
10 hours of machine No 24 at 3d. per hour	0	2	6
12 ,, No 112 at 5d. ,,	0	5	0
8 ,, No. 425 at 1s. 6d. ,,	0	12	0
3 ,, No. 312 at 3s. 2d. ,,	0	9	6
15 ,, No. 390 at 9d. ,,	0	11	3
48 hours' machine work total cost.. ..	2	0	3
Add variable rate at 4·5d. per hour for 48 hrs.	0	18	0

	£	s.	d.
Wages 10 hours at 10d per hour	0	8	4
,, 12 ,, 8d. ,,	0	8	0
,, 8 ,, 8d ,,	0	5	4
,, 3 ,, 18d ,,	0	4	6
,, 15 ,, 9d. ,,	0	11	3
,, 48 ,, Total wages	1	17	5

	£	s.	d.
	1	17	5
Percentage for general unproductive labour (labourers, oilers, etc.), 5 per cent. of productive	0	1	10¼
	£4	17	6¼

The value of this method of distributing manufacturing expense is fully demonstrated by the next example, showing the costs for Dept. IV. of a similar order performed in another month:

CASE B.

	£	s	d.
48 hours' machine time as before	2	0	3
Variable rate 48 hours at 10d.	2	0	0
Wages as before	1	17	5
Percentage for general unproductive labour, as before, 5 per cent. of productive ..	0	1	10¼
	5	19	6¼

The same order, performed in the same Dept. IV., but by different workmen, in another month, gives the result shown in next example:

CASE C.

	£	s.	d.
6 hours of machine No. 24 at 3d. per hour	0	1	6
12 ,, No. 112 at 5d. ,,	0	5	0
4 ,, No. 425 at 1s. 6d. ,,	0	6	0
3 ,, No 312 at 3s 2d. ,,	0	9	6
10 ,, No. 390 at 9d. ,,	0	7	6
35	1	0	8
Add variable rate at 4·5d. per hour for 35 hrs.	0	13	1½
	2	2	9½

	£	s.	d.
Wages 6 hours at 1s per hour	0	6	0
,, 12 ,, 8d. ,,	0	8	0
,, 4 ,, 1s. ,,	0	4	0
,, 3 ,, 1s. 6d. ,,	0	4	6
,, 10 ,, 1s. ,,	0	10	0
	1	12	6

	£	s.	d.
	1	12	6
Percentage for unproductive labour, 5 per cent. as before	0	1	7½
	£3	16	11

Lessons from these Examples. The conditions revealed by these figures are highly interesting, and would have remained unsuspected under the old methods of expense distribution. In Case A the variable rate was 4.5d., showing that trade was good and the machines in nearly full work. In Case B the same job cost 22s. more, the same workmen being employed at the same wages, the increased cost being due to the heavy variable rate of 10d., which betrays the fact that many machines stood idle that month. This shows the bearing of trade conditions on the cost of production. In Case C the factors of cost have varied. In some cases skilled and high-priced labour has been introduced, showing the bearing of the efficiency of the workman on production cost.

Machine No. 24 takes 6 hours of labour at 1s. instead of 10 hours at 10d.; machine No. 425 takes 4 hours of labour at 1s. instead of 8 hours at 8d.; and machine No. 390 takes 10 hours at 1s. instead of 15 hours at 9d. The variable rate is the same as in Case A, but as the machines do the work in less time the machine rate for Case C works out at £1 0s. 8d. instead of £2 0s. 3d. for Cases A and B. The variable rate in Case C is reduced from 18s. to 13s. 11d. *as a result of higher efficiency of the workman*. The wages, which were increased in three cases respectively from 10d. to 1s. per hour, from 8d. to 1s., and from 9d. to 1s., nevertheless figure at £1 12s. 6d. for Case C as against £1 17s. 5d. for Case A, the percentage for unproductive labour falling likewise from 1s. 10½d. to 1s. 7½d. In Case C the total job cost £3 16s. 11d. for labour and factory burden as against £4 17s. 6½d. in Case A, trade conditions being the same. Had the factory in question distributed the factory burden by means of an even percentage for both classes of expense, the same for every month of the year, the loss would have been there all the same, but it would have remained undetected, and the greater the sales at the bad times of the year the greater the losses made.

Unproductive Labour. The percentage of unproductive labour chargeable for each shop is obtained weekly from the pay roll, and is pro-rated over the cost of productive labour for the same period; the indirect charge is thus absorbed in the final cost of production as nearly as possible in accordance with facts. By this system of computation the factory cost of a product is composed of:

(*a*) The cost of productive labour.

(*b*) The cost of productive material.

(*c*) The machine rate for all machines used in the processes of manufacture, charged for the exact time during which they were running.

(*d*) The supplementary rate for the same number of hours as (*c*), covering the undistributed factory expense relating to machines.

(*e*) The percentage covering the cost of all unproductive labour unconnected with the machines.

(*f*) The percentage covering the cost of all unproductive material or supplies, such as brooms, buckets, stationery, soap, etc., unconnected with the machines, computed weekly from the storekeeper's disbursement cards.

The selling cost is found by adding to the factory cost the percentage of general establishment and commercial expense for office salaries, rent, insurance, interest, depreciation on all departments outside the factory itself.

Systems for the Stores and Stock Department. The stores and stock department which cares for all material is one of the first to be systematised. Each of the two terms used for material has a definite meaning. *Stores* denotes raw material and partly or wholly finished articles *purchased from outside*, whereas *stock* consists of finished articles or parts *manufactured by the factory itself*.

Stores are productive when they consist of material or parts used directly to produce stock; non-productive when they consist of supplies for factory or office necessary for the routine work or for the maintenance of the plant, such as emery wheels, grindstones, stationery, files, knives, buckets, twine, brooms, etc.

The Equipment. The store or stock department consists of a room or series of rooms in a central position under the control of a stock keeper, who alone is authorised to make disbursements, and then only on written and signed requisition.

The shelves, bins, and racks should be easy of access, well built, and provided with some mechanical device for registering disbursements, so that the stock keeper may know at a glance what his reserve is. Counting scales and all devices which assist in weighing and counting out disbursements rapidly and with unfailing accuracy should be provided. On the slip-in cards are spaces for inserting the number of the box, the date received and returned empty, the name of stores, number of pieces or quantity, the factory order and requisition numbers, and lines for the signatures of foremen and stock-keeper. The stock keeper needs a cabinet for his perpetual inventory and drawers for a supply of disbursement and other cards. The staff consists of the stock keeper and of one or two assistants without authority to authorise disbursements. The former is responsible for every ounce of material and every unit of stock committed to his charge which must be accounted for. If there be a record office, no clerk will be needed. A number of trucks must be provided for the transport and delivery of material, and the collection of empty boxes, [illegible] to fetch and carry stores on requisitions under any circumstances; the latter are conveyed from the shops to the store department through pneumatic tubes.

Routine of the System. We will suppose that the stock keeper discovers by means of finger signals in the slip of red tabs on the cards of his perpetual inventory that fresh stores are required. If there be a record office he makes out a purchase order after consultation with the record keeper, and sends this order to the general manager for signature; it is then passed on to the correspondence department, where it is duly registered and signed, the duplicate order being sent to the record office. If there be no record office the stockkeeper merely notifies the manager of the purchase department by means of a requisition card, giving the particulars of the purchase.

As soon as he receives the stores, the stock keeper makes out a material received card, giving the number of the requisition order, date, the quantity and condition of the goods; he sends this card to the cost keeper, the freight and lading charges having been sent direct to the cost department from the receiving room. The stock keeper then duly registers the material received and the balance on hand on his perpetual inventory card, as well as on the dial or indicator as he stores the goods in bin, shelf, or rack. In the record office, the requisition cards received by the stock keeper are filed in a week's file as they come in from the stores department, until the weekly stock room disbursement and inventory reports are made out. These show the total disbursements charged to each order,

and to each department, classified as productive and non-productive, or as charge or factory burden. From these disbursement cards, the cost department compiles the factory burden and general expense summaries and computes the weekly machine rate and supplementary rate, the percentage for non-productive factory labour, which are then pro-rated on the output for the week. The cost clerk uses these to determine the factory cost and selling cost for each article on order.

System of Timekeeping. Labour is the most important factor in all business undertakings, and figures as the largest item in the cost of production. We have already considered, in a foregoing section, the advantages of a labour department, and the most satisfactory methods of treating employees. A practical, up-to-date system of timekeeping is required, however, for the working of the cost department. For want of accurate records of the distribution of the labour charged in the pay-roll among the production orders, managers are reduced to guessing or estimating, as it is called. Experience has shown the danger of such an expedient; the workman must furnish two kinds of records, but as the workman is a bad hand at writing, machines are used as substitutes.

The Mechanical Recorder. The Rochester mechanical recorder consists of a clock working in connection with ingenious printing mechanism. A card ruled for every working day of the week, and further divided for morning and afternoon, both *in* and *out*, is taken by the workman on entering from the "out" rack at the side of the recorder. He drops the card into a slot under the dial, presses a lever, and the exact time shown by the clock is printed in the proper space on the card, which then drops into a receptacle. The workman takes it out, checks the entry, thus preventing the possibility of argument on pay-day, and places the card in the "in" rack. Every night after the workmen have passed out, the time-clerk collects the time-cards from the rack and leaves the intermediate set to take their place; one set of buff cards being for Monday, Wednesday, and Friday, the other, blue, for Tuesday, Thursday, and Saturday, the object of this being to enable the cost department to use the cards day by day, for the purpose of checking the job-cards. Timekeeping at the gate is entirely unnecessary and is being abandoned.

The Job-card. Instead of the old-time board, on which the men were expected to enter from memory at the end of the day the time they had spent on each job, the mechanical recorders are used, and the workmen is relieved of all clerical work. The recorder registers the time occupied by each operation, a separate job-card being used for each. The card is prepared before the work is handed to the workman, and bears his name, the date, order number, department number, name and particulars of operation to be performed, the schedule number of the machine or tool used, its hourly rate, the rate of pay of the workman, whether by hour or piece, with a column for extension; spaces are besides provided, under "start" and "finish," for the recorder to register the time expended. The workman having registered "start" pins the card up in front of him until the job is completed, when he takes it to the foreman, who examines it and punches or signs it. The workman goes through the same performance with the recorder to register "finish" on that card, and again "start" on the new card which the foreman held in readiness for him with his next job. If the foreman be alert, not a minute need be lost between jobs, in fact, the latter is held responsible for all such intermediate loss of time.

The foreman forwards the job-completed cards as he receives them from the men by pneumatic tube to the cost department, where they are filed temporarily for the day with other job-cards under the man's name or number. After being balanced with the day time-cards, the job-cards are used by the record office to compile various records such as the comparative cost-card. From the records the manager can see at a glance the workmen who have distinguished themselves and proved most efficient.

Three different labour summaries are compiled by the record office from these two sets of time-cards.

1. The weekly labour summary of productive and non-productive labour for each department which is charged to that department.
2. The total labour summary for the factory (this may be issued by the cost department if preferred).
3. The total labour card for each order, indexed numerically, which is issued as soon as the order is complete, and furnishes data for the detailed complete costs sheet.

Day-rate and Piece-work. Day-rate of pay by the hour is the oldest and simplest method of remunerating labour; it has the disadvantage of placing the employer at the mercy of the workman by making the labour cost of a product entirely dependent on the honesty and skill of the workman. Piece-work carries with it advantages and penalties; it tends to place the workman at the mercy of the employer, in the matter of cutting the rate, but it gives the workman the entire benefit of the increased output per hour. The evils of this system are its failure to safeguard the interests of the workman and the demoralising effects of the penalties it carries; the workman loses, if he be unskilful or slack in making an effort, and fails to make a day's wage at his hourly rate; but, on the other hand, if he be over-zealous, he is certain to find the rate cut, the result being a partial or total relaxation of effort.

The Premium Plan. The premium plan is the fairest of all methods in principle, and is already the most widely practised; its central idea is an equitable division between employer and workman of any profit due to increased output of the latter. It presupposes the payment of the time-rate of wages as a basis, so that to the slow workman a fair wage is assured without fear of penalty, a fixed premium being offered per hour saved on the standard time agreed upon for each job. The premium consists generally of 33⅓ per cent. or 50 per cent. (in the Halsey system), which works out thus:

Supposing the standard time for a job be fixed at ten hours, the tables on next page show the working of the premium plan on the basis of both 33⅓ per cent. and of 50 per cent. premium.

A modification of Halsey's premium plan introduced by Mr. Jas. Rowan, of Glasgow, and known as the Rowan premium plan, is preferred by many. This system gives the workman a premium proportionate to the time saved on the time limit. If a man reduces the ten hour limit by two hours, *i.e.*, 20 per cent., he gets a 20 per cent. increase in wages; if by three hours, a 30 per cent. increase and so on. Here the workman's advantage is greater on the first saving of time, but decreases on the subsequent savings, compared to the other methods, as the saving increases.

WITH A PREMIUM OF 33⅓ PER CENT										
Time expended	Wages [illegible]		Premium		[illegible]		[illegible]		Workman's [illegible]	[illegible] of
Hours	s	d	s	d	s	d	s	d	Pence	[illegible]
10	10	0			10	0	—		12	—
9	[illegible]	0	0	4	[illegible]	4		[illegible]	1[illegible] 44	[illegible]
8	8	0	0	8	8	8	1	4	13	[illegible]
7	7	0	1	0	8	0	2	0	13 1	14 [illegible]
6	6	0	1	4	7	4	[illegible]	8	14 [illegible]	[illegible]2[illegible]
5	5	0	1	8	6	8	3	4	16	33⅓
WITH PREMIUM ON SCALE OF [illegible] PER CENT										
10	10	0			10	0			12	
9	9	0	0	[illegible]	[illegible]	6		[illegible]	1[illegible]	
8	8	0	1	0	[illegible]	0	1	0	13	1[illegible]
7	7	0	1	[illegible]	8	[illegible]	1	[illegible]	14	[illegible]1 4
6	6	0	[illegible]	0	8	0		0	16	33⅓
5	5	0	2	[illegible]	7	[illegible]	[illegible]	6	18	0

Profit sharing schemes for the remuneration of labour are open to many objections, one being that until the custom of frequent balances—say monthly—has become universal the benefit to be derived by the workman is too long deferred. Secondly, the profits or losses of an industrial enterprise depend on many factors with which the workman is not in the least concerned. It is not fair that he should share in either profit or loss except on the item of cost of labour alone in the costs of production, a plan which has indeed been suggested, but which is too complicated in the working to find much favour with master or man.

Labour-Saving Machinery. A false idea obtains credence among the employees in many British factories that labour saving machinery is a menace to the working man. This is mere ignorant prejudice.

There is more scope for skill and sharp wits in working most machines than in accomplishing one manual process indefinitely.

Labour saving machines are not only used in the workshops for manufacturing, but also in cost keeping for the factory, such as the tabulator, to which reference has been made elsewhere in this series. It is a machine which we owe to the genius of America. It has proved of the greatest use not only in industry but to statisticians and others engaged in census work, agricultural and parliamentary returns, in which the rapidity and accuracy with which this electric machine makes computations is of the greatest value. In the factory all the various totals from the time and labour cards or any other, can be added by means of this machine with absolute accuracy in a few seconds. It adds up several columns of figures from the cards as they are fed to it and registers the totals on a dial, adding simultaneously, for instance, the number of hours and quarter hours, and the cost of the labour in £ s d. One clerk calls out the totals or results to the puncher, who transcribes the figures into holes, checking them over with the check, and the cards are then fed into the machines, unless they are to be sorted first into groups.

The Calculagraph. The most prolific source of error in factory cost keeping is undoubtedly the method of recording time, time being the most important element in computing the cost of labour. Experience has shown that the average clerk frequently makes mistakes in recording elapsed time by means of a pencil and clock dial, nor does he always subtract the time of day correctly when furnished with mechanical recorder time cards. There is the additional danger that when looking over a card containing times of beginning and times of stopping, he will mix the records and subtract from the wrong finishing time. The calculagraph saves 50 per cent or more of the time clerk's work by registering the time at which the job began (much as other mechanical recorders), subtracting this from the time of finishing and printing the difference or time elapsed in hours and minutes on the card dropped into the slot. All the workman has to do is to push the card into the slot and pull a lever. The number of calculations this clever machine can make is only limited by the number of cards it is possible to push consecutively into the slot during a given time.

The Addressograph. Another labour saver is the *addressograph*, a useful machine originally intended, as its name indicates, for addressing envelopes or wrappers of regular correspondents or subscribers. It is also adapted for preparing the list of names of the weekly pay roll of workmen. The numbers and names of the men, with the rate of pay, number of department, whether productive or non-productive, are set up in rubber type in small metal frames linked together in an endless chain. The chain when set up is passed over a drum which is made to revolve by pressing a lever with the foot, printing the names etc. in succession on a sheet ruled and printed for the purpose. You may have as many chains of 40 links each as you require to use with the same machine. The pay rolls can thus be made out with great saving of time. The idea can be extended and the machine used for a variety of purposes.

Thexton's Envelope Sealer and Stamp Affixer. This ingenious device automatically seals envelopes fed to it at a rapid rate, weighs and stamps them, registering on an indicator strip the number of letters of each denomination of stamp affixed. This machine is not only a labour saver of the greatest value, but its register also forms a check on the accuracy of the postal account.

Finally, there are date stamps innumerable and other devices well known to all business men. The *[illegible]* is a useful contrivance, not for supplying brains to those who are deficient, but for treasuring up ideas, criticisms, items of new [illegible] data, in fact, which the busy man knows he may find useful some day and yet cannot entrust entirely to a memory overcharged already with detail. Instead of jotting down the ideas in a note book they are jotted down on a leaf from the desk pad. A spare drawer in the desk acts as a brain box. The only accessory which has to be purchased is a set of coloured guide cards with tabs on which may be written a letter of the alphabet or a subject. The *memos* are numbered and then dropped in front of the guide card bearing the initial of the keyword. A sheet of blue paper is kept directly in front of each guide card, on which are written the keywords of the memos, being numbered consecutively, beginning at 1 for each letter of the alphabet, so that you have a complete list of the subjects filed for reference. It is quicker to run your eye down the list than to search through the papers, and the number gives a clue to the location of the particular item wanted in the batch in front of the guide card.

Continued

STEAM TURBINES

The Advent of the Turbine. The Parsons and other Turbines. Details of Turbine Construction

By JOSEPH G. HORNER

BEFORE the advent of the little "Turbinia," in 1894, neither engineers nor the general public had ever dreamed of the possibilities that lay in the steam turbine. Rotary engines in large numbers had been patented and made, but they were mostly unsuccessful. The advantages of the rotary engine are that there are no reciprocating parts to be brought to rest, and to have the direction of their motion changed twice during every revolution of the engine shaft. Hence, the turning effort at the latter is regular, apart from the equalising effect of a flywheel. In fact, so regular is the movement of a steam turbine at the highest speeds that it will run steadily without being bolted down to a bed-plate. Standing with the back to the turbine, it is often difficult to say whether it is running or not. Besides these advantages, there are the absence of slide valves with their friction, and of rubbing parts, such as crossheads and their guides, no crank shaft or crank pins with their bearings, and no reciprocating piston, requiring oil. And especially valuable in marine engineering is the smaller space occupied by the turbine, both in area and in height, in comparison with the reciprocating engines of equal power, the relationship being about as one cubic foot to four.

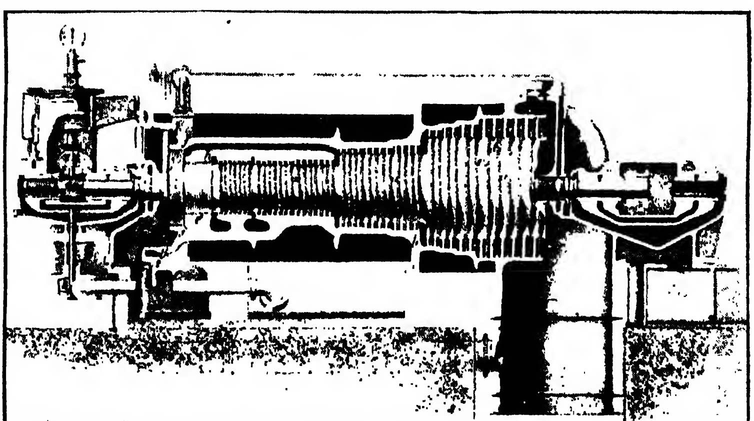
Water and Steam Turbines. Though the water turbine had come into general use, displacing water-wheels in large numbers of cases, it was reserved for the Hon. C. A. Parsons to show how the same essential design could be utilised for steam operation. But steam is highly elastic and water is not, which fact renders several modifications in design and speed necessary; but essentially the steam and the water turbine resemble each other. Each is designed in either reaction, or impulse types of wheels. The idea underlying the two classes of turbines is therefore alike, whether water or steam be used. In each case, instead of static pressure there is dynamic action, the action of a liquid in rapid motion operating either by impact, or through the influence of inertia.

The differences in the two are these: water has a much greater density than steam, and therefore water turbines can be operated correspondingly slower than steam turbines. The latter must have a high velocity: even a moderate velocity is possible only by placing many turbine wheels in series. The high degree of elasticity of steam results in expansions, to utilise which diverging conical jets are essential in simple turbine engines, but are not required with water motors. And when turbines are placed in series they must be of increasing capacities to utilise the successive expansions. Also the result of expansion is to produce condensation of the particles of water mixed with the steam, to increase the friction, and cut away the leading edges of the blades and shorten the life of the engines. Turbines thus differ, it will be seen, from reciprocating engines in the fact that the rotary motion is due to differences in steam pressure, either by reaction or impulse, instead of static pressure between piston and cylinder ends.

Classification. Steam turbines may be classed as compound or multi-expansion; as single expansion, and under a third group, which comprises features of both kinds, with other variations. The Parsons, Rateau, and Zoelly belong to the first, the De Laval to the second, and the Curtis, the Reidler-Stumpf, and some others to the third.

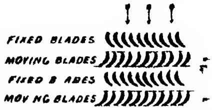
Compound Turbines. The first compound steam turbine, built by Parsons, in 1884, is now in the South Kensington Museum. Without compounding, the moderate speeds required in commercial engines would not be possible. It is easy to expand the steam down to 125 stages by passing it through one high-pressure, and two low-pressure turbines. In 1892 the turbine was first adapted to work in conjunction with a condenser.

The Parsons Turbine. In this [81] the steam is expanded many times, passing through a succession of turbine rings proportioned for small successive drops in pressure. The great advantage of this arrangement is that the steam travels at a very moderate velocity, and the rate of rotation is sufficiently slow - from 100 ft. to 300 ft. surface speed per second—to permit the turbine to be coupled directly to dynamos, screw propellers, fans, etc., without the necessity for gearing down. Moreover, though the expansion at each



81. SECTION OF PARSONS TURBINE

stage is minute in amount, the total expansion over the whole range is large. Actually from 70 per cent to 80 per cent of the total energy in the steam can be delivered to a shaft coupled to the turbine. In view of the fact of great expansion, the value of vacuum is great, more so than in reciprocating engines; hence a good condensing plant is an essential part of the equipment of a steam turbine. An increase of 1 in. of vacuum above 26 in. diminishes steam consumption by from 4 per cent to 7 per cent. In the other direction superheating the steam has a similar effect, and it is therefore practised. Every 10° F of superheat reduces steam consumption by about 1 per cent.

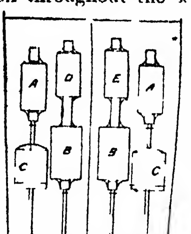


82. BLADES OF PARSONS TURBINE

The design of the Parsons turbine is shown in longitudinal section in 81. Essentially this comprises a revolving drum or shaft, *a*, the "rotor," of large diameter, within a cylinder, *b*, leaving an annular space between the two, which space is occupied by two distinct and numerous sets of rings of blades. The rings *c* which project radially from the spindle are the moving blades or vanes, those, *d*, which project inwards from the casing are the fixed or guide blades, and these alternate with spaces between. By this arrangement the friction of the steam is reduced to a minimum, and the clearances are slight.

Action of Turbine.

The action of the mechanism is as follows. Steam enters at one end, at the left hand of the figure, and travels through the annular space between the shaft and its casing. Coming first in contact with a ring of fixed blades it strikes the first ring of movable blades [see the detail 82], causing them and the spindle to which they are attached to revolve, the relative dispositions of the blades ensuring this movement as in water turbines. The steam thence passes into the next ring of fixed blades and is diverted thereby into the succeeding ring of movable blades [see the detail diagram 82]. And thus this action goes on throughout the series.



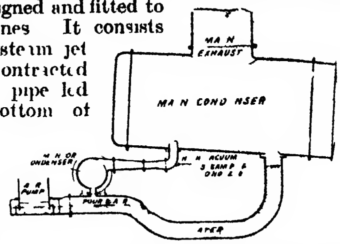
85. SHAFT ARRANGEMENT OF TURBINE MACHINERY (Suitable for warships)

A. High-power turbine. *B.* Low-power turbine. *C.* Condenser. *D.* High-power cruising turbine. *E.* Low-power cruising turbine

It will, however, be noted that the spindle [*a* 81] is made with three diameters. These correspond with three main stages of expansion, because, as the steam continually expands and loses pressure, the blades have to be larger at the low-pressure stages. The blades themselves also increase in diameter along each main stage.

As the pressure of the steam would impart an end-long thrust to the turbine, this is resisted by three pistons, *e*, *f*, *g*, one corresponding with each of the stages of expansion. Communication is made between the steam at each stage and its piston through the three passages seen, *h*, *j*, and *k*.

In order to help in maintaining a high vacuum a new apparatus, the "vacuum augmentor" [83], has been designed and fitted to several turbines. It consists of a small steam jet placed in a contracted portion of a pipe led from the bottom of the condenser. The jet draws water from the latter and delivers it to the air pump through a small auxiliary cooler, so reducing the air to a very small amount.

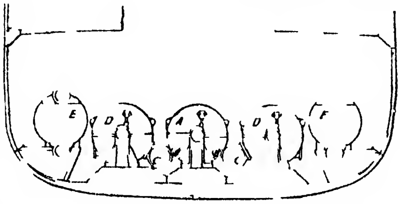


83. PARSONS VACUUM AUGMENTOR

Governing in the Parsons turbines for electric lighting stations is generally effected by a centrifugal governor, which moves a small relay plunger that regulates the steam admitted to a relay which in turn acts on the main steam admission valve, which is usually of the double-beat or balanced type.

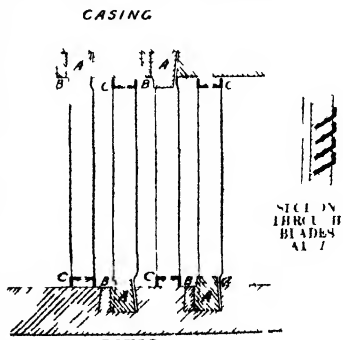
Marine Turbines.

It is a far cry from the little Turbinia of 1894 with her engines of 2,000 h.p. to the vast Lusitania. Step by step the suitability of the turbine has been demonstrated for torpedo boats, destroyers, Clyde pleasure steamers, yachts, cross-Channel steamers, the Atlantic liners, and big cruisers. The advantages over reciprocating engines are numerous, the drawbacks few. The saving of weight of machinery is considerable, the centre of gravity is low down, the steam consumption is less. The drawbacks are those due to the high speed of turbines and the relatively slow speed of propellers, and to the non-reversibility of turbine engines. In warships another difficulty lies in the slow rates for cruising and the high speeds that would be required in time of action. These difficulties are got over by using various sets of turbines, high and low pressure, and for going ahead and astern, each turbine set having its own propeller and shaft. Figures 84 and 85 show arrangements for a Channel steamer and a cruiser. The invention of a reversible turbine would be a source of fortune. In the "Carmania," one high-pressure turbine is



84. CROSS SECTION OF CHANNEL STEAMER "THE QUEEN"

A. High-pressure turbine. *B.* Main steam to *A*. *C.* Automatic closing valve to two low-pressure and astern turbines. *D.* *D.* Low-pressure and astern turbines. *E.* Condensers



86. SECTION THROUGH BLADES OF WILLANS-PARSONS TURBINE

A. Foundation rings. *B.* Caulking strips. *C.* Channel strips

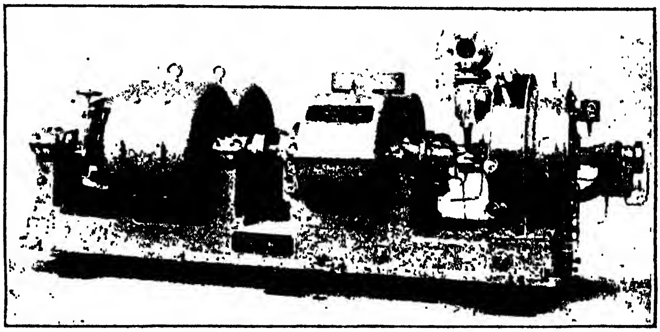
placed in the centre line of the vessel, and two combined low-pressure ahead and astern turbines in the two wings respectively. The turbines make about 185 revolutions per minute. The low-pressure turbine casings are 14 ft. outside diameter, by 36 ft. long. In the "Lusitania" there are four shafts, each driving an independent propeller. On the two wing shafts there are the high-pressure turbines, taking steam direct from the boilers. Thence it passes to the low-pressure turbines on the inner shafts, and thence to the condensers. There are two turbines on the inner shafts for going astern, making six turbine sets in all. The surface speed of the rotor blades is from 100 ft. to nearly 150 ft. per second. At each row of blades there is a drop in steam pressure of about 1 lb. per square inch.

The Parsons turbines have been now applied to vessels of every class, the most notable being the cruiser "Dreadnought," and the liners "Lusitania" and "Mauretania." The total power of marine turbines only, of the Parsons type, made up to the present is 385,000 h.p., distributed as follows: pleasure steamers, 18,200; cross-Channel steamers, 149,900; yachts, 18,100; ocean-going steamers, 91,900; war vessels, 106,900. The total power of marine turbines of other types is about 16,000 h.p. The principal application of the steam turbines as yet has been to marine work and the driving of dynamos in power stations. Their practicability has also been demonstrated in the driving of fans, of centrifugal pumps, of air compressers, and as blowing engines. The total horse-power of turbines of the Parsons type is nearly 2,000,000 h.p.

Fixing the Blades. The difficulties in building up the blades of turbines are immense, since there must be no risk of their working loose and falling out, but these difficulties can be fully appreciated only by those who have seen the operations of building up. In the turbines of the "Carmania" the total number of blades is about 1,115,000. They vary in length, being longer in the low than in the high pressure engines. They have, therefore, to be bound together with circumferential strips, and soldered. Each individual blade has to be fitted in place, caulked, set, and individually inspected. Afterwards there are difficulties in balancing, and in erection of the rotor within its casing.

Messrs. Willans & Robinson, Ltd., manufacture the Parsons turbine, with modifications of their own. One of these relates to the method of fixing the blades, shown in **86**. The blades are built up into segments, usually half rings, both for the shaft or rotor, and the casing. Each blade is stamped so as to form a dovetailed root or tang at the end which is fixed into the segment. The free ends of the blades are riveted into, and protected by, a ring or shrouding of channel section. The blades for a half ring are assembled by lightly riveting the tongue of each blade into the channel shrouding, and thrusting the dovetailed tangs into the slots in the foundation ring. The half ring is then placed in the groove provided for it in shaft, or casing, and there fixed by means of a caulking strip. Afterwards the riveting to the channel shrouding is completed. The dovetailed fitting at the root, with the pressure of the caulking strap, prevents the blades and rings from risk of flying out by centrifugal force.

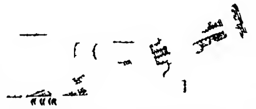
The De Laval Turbine. This [**87**] is a high-pressure or non-compound turbine. The issuing steam expands in the nozzle [**88**] and strikes the bucket of the moving wheel with a velocity of from 3,000 ft. to 4,000 ft. per second, which wheel rotates at a surface speed of about 1,380 ft. per second. The velocities of the wheels are so high that reduction has to be made for driving purposes by means of toothed gears. This turbine resembles in principle the Pelton wheel, and it has but one circle of buckets. These turbines are very remarkable on account of the extremely high speed at which they run, making from 10,000 to 30,000 revolutions per minute, according to size. Steam of any pressure may be used, but the higher the pressure the greater the power developed. A remarkable feature is that whatever the initial pressure the expansion takes place adiabatically down to the pressure which exists in the chamber in which the turbine wheel revolves. The steam is expanded in the conical nozzles [**88**], and this gives a very high velocity of outflow. Professor Zeuner has shown that if the steam is expanded adiabatically in a suitable nozzle all the potential energy of the steam is transformed into kinetic energy, and that the latter corresponds with the amount of work which the same steam would have performed if expanded in the same proportion in the cylinder of an ordinary engine. At 200 lb. initial pressure, steam expanded in a nozzle down to the pressure of the atmosphere has a velocity of outflow of 3,115 ft. per second; or down to 28 in. vacuum, of 4,127 ft. per second. Steam expanded in a nozzle from 280 lb. pressure above the atmosphere down to 28 in. vacuum leaves the nozzle with a velocity of 4,229 ft. per second, or over 48 miles per minute! With such a velocity the jet would pass round the earth in 8 hours 37 minutes. A 300-h.p. turbine wheel which runs at a peripheral velocity of 1,450 ft. per second, and is 31½ in. in diameter, would travel round the earth at the equator in 25 hours.



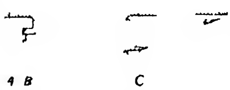
87. 225-H.P. TURBINE DYNAMO

The Nozzles. Much depends on the designs and arrangements of nozzles. A nozzle of a given dimension can pass only a certain quantity of steam at a certain pressure. Thus [**89**], one proportioned for steam of 200 lb. pressure will pass 479 lb. of dry saturated steam per hour, which fact is taken account of to ascertain the steam consumption of turbines. The nozzles are placed at a definite angle with the plane of rotation of the wheel—namely, 20°. The linear velocity of the buckets should be 47 per cent. of the velocity of the steam. The absolute velocity of the steam leaving the buckets

should be 34 per cent of the initial velocity The energy absorbed by the turbine wheel is then 88 per cent of the kinetic energy of the steam The nozzles are only about one sixteenth of an inch away from the buckets, so that there is no loss of velocity The nozzles are proportioned to the pressure of steam Figure 89 illustrates one for 200 lb steam pressure, and 28 in vacuum At the section A where the steam enters the pressure is 200 lb above the atmosphere It is dry and free from moisture In the nozzle B its pressure becomes 110 lb and it holds 4 per cent of moisture its velocity is 1 500 ft per second At C the largest section with 28 in of vacuum the percentage of moisture becomes 24 per cent and the velocity 4,127 ft per second The proportion between the areas of the large and small sections should be 27 2345 The steam nozzles are arranged at intervals round the wheel receiving the steam from a chest in the turbine case Each nozzle has its shutting off valve [88] so that it can be opened or closed at will which permits of working the turbines at reduced load



88 DE LAVAL NOZZLE AND SHUTTING OFF VALVE

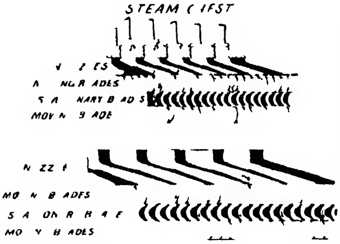


89 DE LAVAL NOZZLE

Flexible Shaft Each bucket has to be fitted separately into the solid wheel the fitting being by dovetails The flexible shaft is an essential detail of these wheels without which no amount of balancing would prevent vibration at the high speeds of revolution A rigid shaft would soon cause ruin to the bearings Using a flexible shaft the vibrations disappear at a certain stage This is not readily capable of explanation but the fact is clear from tests At the early stages of running the shaft vibrates but at what is termed the critical speed the vibration ceases and the shaft runs steadily this stage being termed the settling of the wheel The shafts are small on account of the high speed that for a 300 h p wheel being only 1½ in diameter

The very high speed of revolution has its utilities and its drawbacks It is valuable for the direct driving of dynamos of centrifugal pumps and of fans But reduction gear is necessary for ordinary machinery Double helical gears are used The pinion is cut in one piece with the shaft, and is of hard steel and the teeth of the gearing wheels are cut in a softer steel the linear velocity of the teeth is about 1 000 ft per second The regulation of the speed is by means of a centrifugal governor, fixed on one of the gear wheel shafts which controls a double seated throttle valve

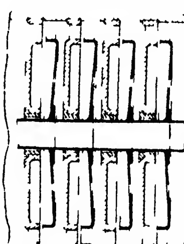
The Curtis Turbine. This is of the impulse type Groups of expanding nozzles are used to convert potential energy into kinetic energy But expansion is also carried out in two or more stages, thus combining the principles of the two main types of turbines already described The number of stages is governed by the degrees of expansion, and by the velocity which is desirable Each stage is separated from the one adjacent by a diaphragm, steam tight, except where nozzles are inserted for the steam to pass into the next stage Figure 90 is a diagram of the relative positions of admission valves, nozzles, and buckets in a two stage turbine The steam coming from the steam chest passes through a series of expanding nozzles thence through two or more rings of moving blades, or buckets on the rotor or shaft Stationary blades on the casing redirect the steam received from the rotating buckets into the next set of rotating buckets, and so on A high steam velocity thus made to impart a moderate speed to the turbine This turbine is of vertical type The steam issues from the nozzles at a rate of about 2 000 ft per second and the surface velocity of the buckets is about 100 ft per second The revolving buckets are cut out of a solid ring by machinery, and so are those in the stationary blades which avoids risk of accidental loosening of these important elements



90 DIAGRAM OF CURTIS STEAM TURBINE

The Zoelly Turbine. This is a multi stage impulse motor It comprises a high and low pressure casing each containing about five elements Steam is introduced into the first set of guides and so passing through the series expands and loses pressure, doing work until exhaustion takes place The high and low pressure casings are distinct but on the same bed plate The number of elements is few in comparison with most turbines and the efficiencies are high

The Rateau Turbine This comprises a series of moving rings alternating with discs fitted to the inside of the casing But it differs from the Parsons in being of what is termed multi cellular type [91] That is the moving vanes are fixed to the peripheries of flat wheels separated from each other by diaphragms which divide the interior of the turbine into cells Each element in a single cell comprises one distributor and one moving wheel It is claimed that very considerable play can be left between moving parts in this design which facilitates construction and lessens risk as wear takes place Also the pressure is uniform there is no longitudinal thrust on the moving parts Vanes of cylindrical form are riveted on the peripheries of the discs and a steel band riveted to the vanes These moving wheels turn between circular diaphragms provided with distributing vanes which enter circumferentially into grooves formed in the interior of the turbine casing



91 DIAGRAM OF RATEAU TURBINE BLADES

The mathematics of turbine engineering must be studied in works devoted to the subject The real difficulties are those due to construction, consequent on the large number of buckets, the high rates of rotation, and the evils of wear There are other turbines besides those named, but up to the present time these have been the most successful There are types in America and Germany little known here, many engineers are also now working at the problem of a gas-driven turbine.

Continued

NON-TEXTILE DYEING

Broad Principles of Dyeing. The Methods Employed in Colouring Leather, Paper, Straw, Grass, Wood, Chip, and Feathers

Continued from page 6594

By HERBERT ROBSON

THIS course cannot pretend to be exhaustive, for the subject itself is almost inexhaustible. It is obvious that there must be many omissions in view of the vast number of articles that are coloured artificially for one purpose or another. The aim, therefore, has been to describe the methods of dyeing of as long a list as possible of the principal commercial commodities.

It is very evident also that the scope of the course does not allow anything approaching a full account of all the processes used in dyeing such goods as leather, for instance. Volumes have been devoted to this subject alone, and the aim of this course must be to indicate the broad principles upon which the dyer works in treating each material. This, however elementary, should be of service. In all branches of dyeing the first thing the craftsman must master is the broad principles of his art. This knowledge acquired, the rest is a matter of experiment and practice.

In this article we shall consider briefly the dyeing of leather, paper, straw, grass, wood, chip, and feathers; in the concluding articles we shall study briefly the processes of dyeing marble and stone, sand, horn, ivory, vegetable ivory, bone, mother-of-pearl, celluloid, glue, gelatin and soap.

Leather. Leather dyeing proper, carried out with dyes in solution, must be distinguished from leather painting. It is a very common practice to colour leather with pigments, but in this case it is simply a question of mechanical adhesion of the colour to the surface, and the methods do not come properly under the head of dyeing.

In leather dyeing proper, the effect produced depends upon three perfectly distinct causes. One of these is the mechanical inclusion of dyestuff in the pores of the material—that is, its imprisonment in interstices which nothing can reach except a liquid. In these spaces the dye is deposited in the solid form by the evaporation of the solvent, and is protected from external agencies by the surrounding walls of leather.

The second cause is the chemical combination of the dye with the leather material itself. Like wool and other animal substances, leather has a strong affinity for certain dyes.

The third is the production of a lake by combining the action of the dye solution on the leather with that of a mordant. When tannin or chrome is used in preparing the leather from the raw hide, it may be made to play a double part by acting as a mordant as well.

As regards the dyes used, their number is very large, and if proper care is taken, almost any dye on the market may be used for leather. Some of them require an acid, some an alkaline, some a neutral bath. The choice of dyes and methods depends also upon the manner in which the hide has been tanned. There are three principal methods. One is with inorganic salts, especially with those of chromium and iron; a second is with tannin from oak bark, or very commonly from sumach, while the third is chamoising, or preparing the skin with an animal fat, such as fish or horse oil. It is easy to see that if these methods are combined, as is often the case at present in the preparation of the same lot of leather, the difficulties of the dyer, who has to regulate his procedure by the chemical nature of the leather, are much increased. The following table of analyses will show this forcibly.

—	Oak bark tanned leather	Mineral tanned leather	Chamois leather
	Per cent	Per cent	Per cent
Water	18 0	25 0	22 0
Leather	72 9	59 0	66 0
Uncombined tannin	4 7		—
Ash	0 8	15 65	2 0
Fat	0 8	0 3	10 0
Unaccounted for	2 8	0 05	—
	100 0	100 0	100 0

Of the 10 per cent of fat in the chamois leather, 6 per cent are in combination with the hide substance and 4 per cent in excess.

These figures clearly show that the procedure must be very different for the three sorts, although the dyes used are practically the same in all cases, and depend solely upon the colour to be produced. It is often stated that the form of tannin used has an influence on the dye—that sumach tanned leather, for example, cannot be dyed in the same way as oak bark tanned leather. This is quite a mistake. The active ingredient in the tan, if not identical in all cases from the chemical point of view, is so from the standpoint of practical results.

Dyeing Varieties of Leather. The main principles underlying the dyeing of the three sorts of leather may be stated briefly. With oak bark leather, or other leather tanned by natural tans, attention must be paid to two points, namely, the natural affinity for dyes of the leather itself, and the utilisation as a mordant of the free tannin present in excess, so as to save in the use of other mordants. With chrome leather, or other minerally tanned leather, regard must be had to the lake-forming properties of the metallic oxides present. They must be utilised as mordants as far as possible.

In the case of chamois leather we have to rely either upon the chemical affinity of the dye for leather, or upon mordanting, or to take advantage of both. In the first two cases, of course, the absorption of the dye into the pores, already noticed, takes place, and is by no means a negligible factor in the result. As regards chamois leather, however, it is in many cases necessary to remove the superfluous grease before dyeing, as its presence not only hinders the absorption into the pores, but by forming, as it were, an insulating layer, it prevents due contact between the fibre and the chemicals used for the purpose in hand.

The dyeing of bark-tanned leather is dependent entirely upon the previous treatment. It is quite impossible to dye properly a badly tanned leather. The flesh side must be perfect, or no care will prevent

the formation of streaks and spots. The tan must also be uniformly distributed through the entire mass of the leather, or the same results will ensue. When a leather has been dyed which is nearly but not quite faultless in these respects, it may seem unexceptionable on leaving the dyer's hands, but it will be sure to develop unlevelness of shade after exposure to atmospheric influences. If the dyer finds that a sample of the leather does not dye uniformly after careful washing, he should retan it with sumach. This does a good deal towards securing uniformity.

Dyes for Leather. Tan leather is dyed with coal-tar dyes, with colour lakes, and also with direct vegetable and mineral colouring matters. Nine-tenths of the leather dyed is dyed with coal-tar dyes. The number of dyes used is very great, and several different processes are therefore in vogue. Genuine russia leather is dyed black with logwood on a mordant of alum and copperas, and red with sanders wood on an alum mordant. Other colours are dyed with anilines. Most dyers use logwood for black, and for ordinary leathers a tannin mordant is used, the full black being secured with a little fustic. Many, however, use nigrosine. For brown shoes, Azoflavine RS and Fast Brown are largely used.

In dyeing with coal-tar colours which require a mordant, lactic acid, bichromate, tartar-emetic, yellow prussiate, and the sulphates of alumina, iron and copper, are those chiefly employed. Most of the coal-tar colours used are, however, substantive dyes, and the shade is regulated by the strength of the bath—that is, by the amount of dyestuff absorbed by a given amount of leather. Tannin-dyed leathers take neutral or basic dyes without a mordant, and acid dyes, if mordanted with the appropriate mordant. Alum-tanned and chrome-tanned leather take acid dyes substantively.

The great object to be gained on tanned leather used for bootmaking and in upholstery is fastness to light. In the case of boots, the dye is, or ought to be, protected from weather by the usual dressings. Hence the dyer picks such dyes as are fast to light, and when possible, those which require no mordanting. It has been found that if bark-tanned leather is painted over with an ammonical solution of an alizarine, and then mordanted with alum or iron, a good colour can be got without much heating, which would tender the leather. It is found that the use of iron or aluminium salts as basic as possible is desirable, as the neutral salts do not easily form lakes with alizarines, so that a good deal of the dyestuff is wasted. Basic nitrate of iron appears to answer every requirement in this connection, and is effectual at a temperature which does not exceed what is bearable by the hand.

Dyeing Chrome Leather. Chrome leather dyes directly with great ease with any acid coal-tar dye, the only precaution necessary being that the leather should be thoroughly wetted before entering into the dye-bath. For neutral or basic aniline dyes a previous mordanting with sumach is necessary for light shades. For darker shades the sumach is replaced with fustic, and for the darkest with a mixture of fustic and logwood. Alizarine dyes answer very well for chrome leather because the material stands the high temperature reqnired, which bark-tanned leather will not do, except by the special treatment ab ve mentioned. They are also particularly good on chrome leather because chrome is the best mordant for alizarines generally. Lactic acid is a very useful assistant mordant for chrome leather if specially fast shades are required. It should be pure, however, as impurities are extremely apt to produce unlevel shades, especially with dyewoods or sumach.

Chamois leather can be mechanically coloured by rubbing in any desired pigment. If, however, it is to be dyed with a substantive or adjective coal-tar dye, it is freed from fat by washing and then dyed exactly in the same way as tanned leather. For light shades a preliminary bleaching is usually necessary, and this is usually done with sulphurous acid and permanganate of potash. When the leather has become a full brown by impregnation in the permanganate solution it is rinsed, and put into sulphurous acid solution just sufficiently long to remove the precipitated oxide of manganese. It is then rinsed and dried. Sulphurous acid alone cannot be used as it tenders the leather and does not bleach it thoroughly.

Dyeing Paper. Although the mineral colours are largely used in dyeing paper, the artificial dyestuffs are destined to take the first place in paper dyeing as in wool and cotton dyeing. While the earliest procedure was to amalgamate the dye with the size and thus to apply it to the paper after manufacture, it has now been found much better to dye the pulp, thereby securing the colouring of the paper through its whole thickness. This operation is by no means so difficult as cotton or wool dyeing, inasmuch as it is only necessary that the colour should not rub off, should be fast to light, and should not injure the cohesion of the paper. Hence, the paper-maker has a very large choice of dyes, and as the mineral dyes are especially cheap and fast to light, his preference for them is easy to understand, although they act prejudicially upon the durability.

The most usually employed of these mineral dyes are ochre, chrome-yellow and chrome-red, Prussian blue, ultramarine, graphite, and lamp-black. These must be added to the pulp (after having been ground as finely as possible), either in a pulp mill or in a vat provided with a stirrer. The stirrer is necessary with heavy substances such as red-lead, litharge, chrome-yellow, manganese, etc., on account of their great tendency to settle to the bottom of the vat.

Some few mineral dyes can be actually made in the pulp, as, for example, Prussian blue, by adding to the pulp ferric chloride and potassic ferrocyanide, ochre by adding ferric chloride or ferrous sulphate and milk of lime. The two reagents are added in succession, and it is most important to mix the first thoroughly with the pulp before adding the second, and yet not to allow it time to penetrate into the interior of the fibres. Neglect of these precautions will produce want of uniformity in results as well as waste of colouring matter, for more of the latter will be required to produce the required depth of shade. By generating the dye in the pulp itself it is got in a finer state of division than is attainable by grinding, so that the colours are brighter and more uniform.

Mineral Dyes for Paper. It is, perhaps, unnecessary to say that the fineness of the tints depends also upon the constitution of the pulp, and for pure lively colours the latter must be carefully chosen or previously bleached. When the pulp contains coloured rag, it can only be brought to a different colour by concealing the first, and for this the coal-tar colours are most suitable.

The following is a brief account of the mineral dyes most commonly used:

Reds—Red-lead and cinnabar. Almost disused now on account of their high specific gravity and of the greater cheapness of aniline reds.

Yellows and Oranges. Chrome-yellow, which is absolutely fast to light, is the best yellow. By adding reds to this, any desired orange hue can be obtained. Ochre is best generated in the pulp, as directed above, on account of the labour required to grind and levigate it properly. If levigated chalk is used instead of quicklime to form the ochre, the froth produced by the escape of carbonic acid can be easily got rid of by pouring in a little petroleum. Ferric chloride is better than ferrous sulphate, as when the latter is used the proper colour is reached only when the ferrous salt has become oxidised by the air, and for this time and stirring are necessary.

Blues. Turnbull's and Prussian blues are readily generated in the pulp, and are even to this day unsurpassed by any coal-tar colours. In using ultramarine, any excess of acid or of sulphate of alumina must be absent from the pulp as both destroy the colour.

Greens. Brunswick and many other poisonous greens have now been entirely displaced by a mixture of Prussian blue and chrome-yellow, or by coal-tar colours. Seventeen parts of the chrome-yellow and one of Prussian blue gives an almost pure green. Different shades are, of course, procured by altering these proportions.

Blacks. Of special importance for grey shades of black are lampblack and graphite.

Vegetable Dyes for Paper. As regards vegetable dyes, logwood, fustic, and cutch are chiefly used on account of their cheapness and comparative fastness to light. Saffron, madder, annotto, and indigo have been driven from paper-dyeing by better or cheaper products. Logwood is used either for darkening other dyes or for making a lake of a dirty violet hue by boiling the logwood extract with tin salt. This lake is used with iron salts for grey and black papers.

A splendid black is secured by the following process: A clear solution of cutch in hot water is added to the pulp. After an hour a weight of bichromate of potash equal to one-fifth of that of the cutch is added, and after another hour one-fourth of the same weight of alum. After yet another interval, logwood extract and nitrate of iron are added till the black is deep enough. Any desired blue shade can now be imparted by judicious additions of ferrocyanide of potash.

Coal-tar Dyes for Paper. The coal-tar colours are mostly soluble in water. If they were used for paper in the same way as for fabrics most of the dye would run off in the waste water from the machine wires. It is, therefore, necessary to precipitate the dye in an insoluble state upon the fibres of the paper—that is, to use mordants, except in the case of one class of dyes, to be mentioned later. The size, however, constitutes a very suitable fixing medium for coal-tar dyes, whether it be made from resin or wax.

Solution of resin soap, when mixed with sulphate of alumina, gives a gelatinous precipitate of the aluminium salt of abietic acid. This precipitate has a great advantage over that obtained with ordinary soap in that it does not clot together, but remains in a perfectly uniform and purely divided state. This is a most important property, because the alumina-soap precipitates act as mordants, and do not give a uniform tint unless they remain in a state of minute subdivision. Not without importance, too, is the bulk of the precipitate, for the spreading of the dye over a large surface gives more brilliant hues. But resin size has yet another advantage as a mordant, for it answers equally well both for acid and for basic dyes, whereas tannate of antimony in cotton-dyeing can be used only for basic dyes. From the possession of this valuable property by the resin soap it follows that different proportions must be used according to the nature of the dye.

Fixing Dyes on Paper. In order to test the fixing power of the size for a particular colour an experiment must be made, adding in each case 5 per cent. resin soap to the pulp, then the proper amount of sulphate of alumina, and lastly the dye. The waste water from the machine wires should be colourless, or nearly so, and this test made with a large number of dyes has shown that the basic coal-tar colours answer best.

But even they will not do for a paper containing less size than the above unless 2·4 per cent. of tannin and as much acetate of soda is also added to the pulp. This addition is desirable, even with strongly sized pulp, if dark shades are required. Bismarck Brown and Saffranine have, however, so much affinity for cellulose that the tannin and acetate of soda are rarely required for them. Too quick drying and too hot calendering have a more or less bad effect upon most of the aniline colours and prevent the production of really lively tints.

The direct cotton dyes answer splendidly for paper, whether sized or not, but their high price has hitherto caused them to be little in demand among paper manufacturers, except for *papier de luxe.* In the first rank of them for pulp dyeing stand Erica, Brilliant Yellow, Chrysamine, Oxyphenine, Congo Brown, and Diamine Black. The process of using these substantive dyes is to size first, then to neutralise any excess of acid with the smallest possible quantity of soda, and then to add the dye. If the waste water is not properly clear, a little Glauber's salt may be added.

Dyeing Straw. Straw consists of the stalks of grasses, more particularly the cereal grasses, and of leguminous plants, such as beans and peas. The value of straw depends upon its length and toughness, as regards the dyer's point of view, and in both these respects rye straw probably holds the first place.

The farmer and the dyer are not at one with regard to straw. With the former its chief function is necessarily that of being a support for the grain, which is thus exposed to the ripening action of the air and of the sun. Straw from the threshing floor is, however, not exactly what the dyer wants. From his standpoint it has been allowed to grow too long. It has acquired with age a closeness of texture and a marked colour of its own which make it very unamenable to his processes. It is also generally somewhat damaged during the threshing. The strong colour it acquires prevents any but very dark shades being dyed on it without previous bleaching and is very difficult to discharge, while the closeness and resistant nature of the siliceous external skin of the straw is very unfavourable to both bleaching and dyeing.

Straw Suitable for Dyeing. Hence, straw intended for hats is obtained from grasses (usually wheat, which is largely cultivated for this purpose in Tuscany) grown solely from the point of view of straw production, and the plants are cut down before they are thoroughly ripe. The straw is then bleached in the sun on grass, exactly as linen is, with occasional sprinkling with water.

If chemical bleaching is resorted to, chlorine is the most reliable agent, although peroxide of hydrogen or sodium answers nearly as well. Chlorine is apt to tender the straw, especially if its action is

unduly prolonged or if the straw is not well rinsed afterwards. Sulphur bleaching is usually only temporary, the straw gradually returns to its original colour on exposure to air and light. Permanganate has been used with success, but it is troublesome to work with, and requires very careful watching. All chemical bleaching weakens the straw more or less.

Preparing Straw for Dyeing. The preliminary treatment before dyeing consists in softening the fibre as far as possible in order that the dye may penetrate. At the same time the process removes all grease and other foreign bodies which would cause unlevel dyeing, as well as any sap which may still remain in the straw. This softening is usually effected by soaking first in a weak lye of carbonate of soda, and then in water, which may be used cold, warm, or boiling according to circumstances. No rules can be given except to try cold water first, and warm before boiling water. A little experience will soon enable the dyer to tell by the feel when the straw has been made permeable enough. Steaming is sometimes resorted to instead.

Dyewoods were formerly largely used, and in point of fact almost exclusively, and they are still in current use for the purpose, especially Brazil wood and logwood, but nine-tenths of all the straw dyeing nowadays is done with coal-tar dyes, with or without a preliminary bleaching, according to whether the colour is to be light or dark.

Dyes for Straw. Coal-tar dyes should be chosen which are soluble both in alcohol and in water, as strong tinctures of such dyes can be kept in stock and diluted with water as required for use. Substantive dyes are those chiefly used, and the only requirements which have to be fulfilled are good colour and fair fastness to light. As examples of favourite dyes for straw dyeing we may mention Eosine, Rose Bengal, Naphthalene Yellow, Safranine, Phosphine, Malachite Green, Acid Green, Bismarck Brown and Methyl Violet.

As a general rule, mordanting, when necessary, has to be done at the boil and the dyeing also. Although substantive dyeing of straw can, as a rule, be done without boiling, it is advisable to boil even with substantive dyes, if great fastness is desired. The time of boiling varies with the mordant and the dye, and the mordanting and the dyeing may each take from half an hour to two hours, according to circumstances.

Dyeing Grass. Most grasses, like plant fibre in general, can be easily dyed in fairly durable tints, and all dyes which can be employed for wood or straw are suitable for grasses. Practically, nowadays, coal-tar colours are almost exclusively used and most of them require no mordant. The extracts of cutch, curcuma, the redwoods and logwood are, however, sometimes employed. For light shades the grass must, of course, undergo a preliminary bleaching, which is done exactly as with textiles, and in all cases the grass must be thoroughly soaked in lukewarm water before being placed in the dye-bath. If this precaution is neglected the inequalities always existing in the texture will cause unlevel dyeing.

Aniline dyes are kept by the grass dyer in concentrated solutions in water or spirit, which are diluted for use as required. The bath must be made of a material which has no action on the liquor. There is nothing better than stone-glazed earthenware or enamelled iron. The vessels used must be deep enough to give the grass full play and to prevent any chance of damage to the stems. After dyeing it is usually advisable to give a gloss to the material. It is better to do this as late as possible, as there is a danger of impairing the lustre if operations are carried out after the dressing. The glossing agents employed are gum, preferably gum arabic, but for cheap articles, dextrin, oil, and gelatin will do. Gum or oil can be added to the dyebath or can be rubbed in after dyeing by means of a rag dipped in mucilage or oil. The goods must be made quite dry afterwards by rubbing with clean cloths. If gelatin is used it should be dissolved in lukewarm water with a little alum and soap. The solution is applied with a sponge. In all cases brushing and ironing the dry material enhances the gloss considerably.

Dyeing Wood. Woodworkers rarely call their tinting processes dyeing, but rather staining. This distinction has arisen from the fact that in earlier times wood was always coloured by the use, not of dyes, but of colourless liquids which produced various colours on coming into contact with the woody fibre. For instance, lead salts by reacting with the cell contents of the wood produce colour compounds. This method of dyeing wood was confined to the production of dark shades and is now entirely neglected, although it gives the fastest colours. The reason of this is that the effect of the stain depends upon the age and upon the degree of seasoning of the wood.

It is, therefore, very difficult to obtain any given colour if we depend upon the chemical reactions above indicated, and nowadays, when rapid work is essential, the coal tar colours are chiefly relied upon with two important exceptions—permanganate of potash and the dyewoods. As is the case with bone and ivory, the colour is largely dependent, as regards fastness, upon penetration. Hence, for dyeing proper, every facility must be afforded for this penetration.

Another point is that the penetration must be as uniform as possible, and this can be ensured only by cleaning the surface and making it as level as possible by planing and sandpapering. The durability of the colour can in any case be greatly increased by varnishing the dyed wood with a colourless varnish. It is true that these varnishes are rather expensive, but for ornamental work in wood the extra expense is in many cases justifiable. The best varnishes are solutions of bleached shellac in spirit or the best copal varnishes.

Bleaching Wood for Dyeing. A good bleach bath for wood is made by dissolving 8 lb. of pure oxalic acid, or 4 lb. of concentrated sulphuric acid and 3 lb. of oxalic acid, in 50 gallons of cold, soft water, and then slowly stirring in 5 lb. of sodium peroxide. The bath is then made alkaline, if it is not already so, with more peroxide, or with waterglass. The wood is soaked in this at from 70° F. to 100° F. until bleached. It is then rinsed, soured in very weak acid, again rinsed and dried. The time required for the bleaching varies, of course, with the thickness of the wood. A few days will bleach wood a fifth of an inch thick. Another bath is made from peroxide of hydrogen and ammonia. Neither peroxide nor ammonia injures the wood nor the health of the worker.

Wood is dyed by brushing over it a solution of the dyestuff, or by immersion in the dyebath. The method may be preceded or followed, as the case may be, by the application of a mordant also in solution. The solutions may be applied hot or cold,

and the selection of the temperature depends both upon the nature of the wood and upon the nature of the solutions applied. When they can be used cold, the results are generally more durable, but with many close-grained woods, such as ash, walnut, oak, etc., it is impossible to get sufficient penetration except with hot solutions. The general rules to be regarded for particular colours will now be briefly described.

Dyeing Wood Black. Black is dyed substantively by soaking the wood in, or by painting it with, a substantive coal-tar black. Any substantive cotton dye will answer the purpose well. Another method is to paint the wood alternately with bichromate of potash and with solution of extract of logwood. It is usual here to make the first coat with logwood. It is essential to use the logwood first, and to allow the wood to dry before any subsequent painting with logwood. Want of uniformity is sure to result if these rules are not observed. Sulphate of copper or nitrate of iron can be substituted for the bichromate. The iron salt, however, gives a black free from the shade of green which is very apt to accompany a copper black. An excellent black is also got by alternate applications, whether by painting or by soaking, of pyrogallic acid and protosulphate—or, better, pyroligneate of iron.

Dyeing Wood Brown. Brown is always dyed with a basic aniline dye, such as Bismarck Brown, or with permanganate of potash. This salt gives a fast brown, due to the deposition of oxide of manganese in the fibre, and is much used for staining floors and furniture made of deal and other pale woods. It must, however, be remembered that the colour is the result of a reduction of the potash salt, and therefore of an oxidation of certain constituents of the wood. This consideration shows that there is some risk of impairing the strength of the wood. Permanganate is therefore more suitable for unseasoned than for seasoned wood. In the former the sap-constituents still existing in the wood are those which undergo most of the oxidising action. In this way the wood is not only seasoned to some extent, but the cellulose, its essential ingredient, is left unaffected. The sap-constituents, too, are not without their effect in binding the colour by forming lakes. Permanganate solution must never be used too hot, especially on unseasoned wood, as the differences in affinity will then certainly cause unlevel dyeing. It is also much better, for the same reason, to apply a weak solution of permanganate several times than a strong solution once or twice.

Cutch is sometimes used for dyeing wood brown with a bichromate mordant, applied either before or after the dye. All other colours are dyed almost exclusively with coal-tar dyes, and it may be generally said that all direct cotton dyes will serve for wood if used with the proper precautions. The selection depends greatly upon price.

Fuming Oak. Two exceptional methods remain for notice. One is the darkening of oak by exposure to ammonia gas. The wood is exposed to the fumes arising from dishes full of concentrated ammonia solution in a closed chamber. Old oak is very effectively imitated in this way. The other is the production of a mercury red, which not only gives a very brilliant colour, but acts as a perfect preservative if the wood is not exposed to outdoor influences. The wood is soaked first in a solution of iodide of potassium, and then in one of corrosive sublimate. Full time must be given for the penetration of the first solution before the second is used. A convenient strength for the iodide of potassium is 1 oz. in 1 lb. of water. The sublimate solution must be weaker, say one-third of the strength. When the desired colour has been obtained the wood is thoroughly dried and then oiled and polished.

Dyeing Chip. Wood chip and plaited straw, largely used for hats, are dyed very simply after the fashion of wood and straw respectively. Since artificial silk was introduced, however, "satin chip" is often used, and the unwary garment dyer who treats this like wood or straw, with which it is sometimes mixed, is aghast at the result. Satin chip is natural, or more usually artificial, silk threads pasted together side by side with gelatin into a flat ribbon. For cheaper tapes, cotton, jute, or hemp are used instead of silk.

Dyeing Feathers. Before feathers can be dyed or bleached they must be cleansed from dirt and grease. This is done with warm soap-and-water. Rinse afterwards, first in warm and then in cold water. If preferred, the feathers can be cleaned with petroleum ether. The best bleaching agent, and one which does not injure the feather, is peroxide of hydrogen. The bleaching liquid consists of peroxide of hydrogen of 30 per cent. made neutral with ammonia, so that it does not redden blue litmus paper. The bath is used undiluted for obstinate colours, but should be diluted with water whenever possible. It must not be stronger than necessary, and it can always be strengthened by adding more of the strong bath, some of which should be reserved when the rest is diluted. The feathers are totally immersed, and the bath is covered up to keep out dust and light. It is best to put it in a dark place. The bleaching usually takes about twelve hours. The feathers are then rinsed in soft water, and dried without artificial heat. If kept well covered and shielded from light, the bleach bath can be used several times without renewal.

Dyes for Feathers. The subjoined three dyeing methods have been found to be the best.

A. Dye at the boil in a neutral bath with one of the following dyes: Chrysoidine AC crystals, Vesuvine 4 BC, Phosphine extra, Leather Yellow OG, Leather Red OGR, Leather Brown O, Safranine Red O, Azophosphine GO, BRO, Fuchsine, Cerise GR, Grenadine O, Safranine O, Methylene Violet, Methylene Green, Methylene Grey, Malachite Green crystals, Brilliant Green, Coral Black H.

B. Dye at the boil in a bath acid with sulphuric acid with one of the following dyes: Acid Fuchsine, Orseilline RB, Bleu de Lyon RR, Cotton Blue No. 2, China Blue No. 2, Patent Blue VA, Fast Blue OR, Bordeaux GBR, Deep Black G, Fast Blue Black C, Naphthalene Green V, Azo Yellow conc, Victoria Yellow, Orange II, Fast Brown O, Ponceau GR, RR, Fast Red O.

C. Dye in a bath acid with acetic acid with one of the following dyes: Rose Bengal GB, Phloxine GO, Rosaline OB, OT, Rhodamine O, 4 G, Eosine AG, Erythrosine. Any mode shade can be got by combining these.

The feathers are finally rinsed and dried. They are curled over a small charcoal fire, into which a little sulphur is thrown when white feathers are being curled, and a little sugar when coloured feathers are under treatment.

Very beautiful effects can be got by spraying the feathers with very minute drops from a sprayer. In this way different parts of a feather can be dyed different colours, and the various hues may be made to pass gradually into one another.

Continued

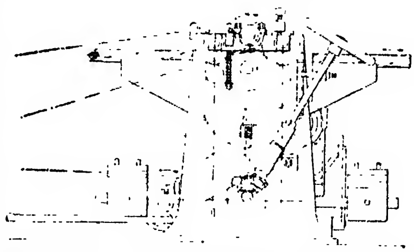
PLANING & MOULDING MACHINES

Trying-up Machines. Panel Planers. Four-cutter Planing and Moulding Machines. Vertical Spindle Moulders. General Joiners

By FRED HORNER

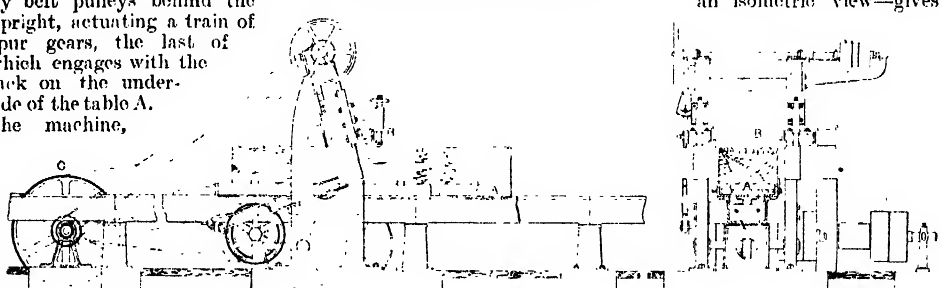
Trying-up Machines. Before describing other classes of planers which bear resemblances to those illustrated in the previous article, we have to notice a particular type of planer—the *trying-up* machine—which is adapted for truing up heavy pieces of timber. Such timber is often too irregular and hard to pass through a roller feed with true results, so they are clamped to a travelling table and fed under the revolving cutters, leaving the planed face quite flat. The general form of the machine is represented in **56**—Messrs. A. Ransome & Co., Ltd., Newark-on-Trent—which shows the timber gripped on the travelling table, A, passing under the adze block at B (covered with a guard). The height of the adze block spindle is adjustable, by sliding it up or down the sloping housings, through hand, or belt, operating vertical screws. The driving of the spindle is by belt from the countershaft C at the rear. The traverse of the table, from 15 ft. to 30 ft. per minute, with a quick return of 80 ft., is effected by belt pulleys behind the upright, actuating a train of spur gears, the last of which engages with the rack on the underside of the table A. The machine, which takes wood up to 20 in. by 20 in., is adapted not only for plain, large work, but can be used for truing and planing a large number of moderate sized pieces, such as the parts of doors, packed together on the table. Moulding and grooving can also be done by replacing the plain adze block with suitable cutters; and in machines provided with additional vertical side spindles, carrying cutter blocks, the edges of timber can be planed. Some trying-up or squaring-up machines have a large disc holding a set of cutters, and mounted on a vertical spindle. The results turned out on these machines are very accurate, but they are rather slower in output than the types with horizontal adze block. A roller feed is fitted when necessary to the tables of trying-up machines for the continuous feeding of thin boards, which do not require to be clamped by the table dogs.

Panel Planers. The surface planing and thicknessing machines, or *panel* planers, which are used for all classes of boards and panels of moderate size, are constructed to pass the timber over a table, above which the cutter cylinder is revolving. The thickness is varied by altering the height of this table. In **55**, a machine by Messrs. John McDowall & Sons, it will be noticed that there is a considerable resemblance in outline to the combined planer shown in the previous article [**54**, page 6452]. The *over-hand* table is omitted, but the other arrangements are much the same. The raising of the table is effected by the inclined shaft and hand wheel, communicating by bevel gears to the vertical elevating screw.



55. 24 IN. × 7½ IN. SURFACE PLANING AND THICKNESSING MACHINE

Another variety of these machines is the *two-side* or *double* surfacer, which has two cutter cylinders, one above and one below, so that a board or panel is finished at one operation. In **58** we illustrate the Whitney planer, one of the most successful types—Baxter D. Whitney & Son, Winchendon, Mass., U.S.A. The photograph shows the external appearance and the arrangement of the countershafts. The drawing [**60**]—an isometric view—gives a section taken longitudinally, and is lettered for comparison with the list of names of parts beneath, which are mostly self-explanatory. It may be mentioned, however, that the lower rolls are supported, and raised or lowered, upon inclined planes, instead of with screws, thus forming a solid bedding and a perfect resistance to the effects of the rapidly revolving cutters, which may be likened to a series of blows, as they strike the wood. Another important feature is the *pressure bars*, necessary on such planing machines. They are placed in front and behind the cutter cylinders, and hold the timber down firmly, affording support to the fibre close to the knives, so that it cannot splinter or tear out. The front bar acts as a *chip breaker*, a small steel spring being placed beneath it, so that there is no risk of tearing out the wood at cross-grained places. The feeding rolls are made sectionally, each being built up of a number of rings which are fitted with spring devices, so

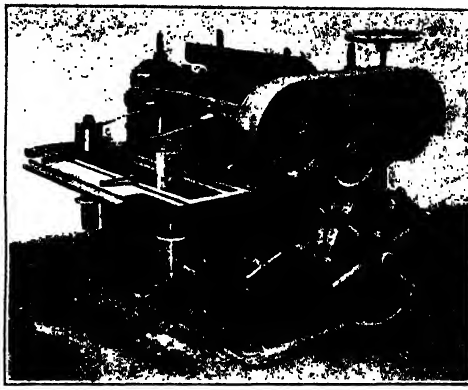


56. 20-IN. TRYING-UP MACHINE

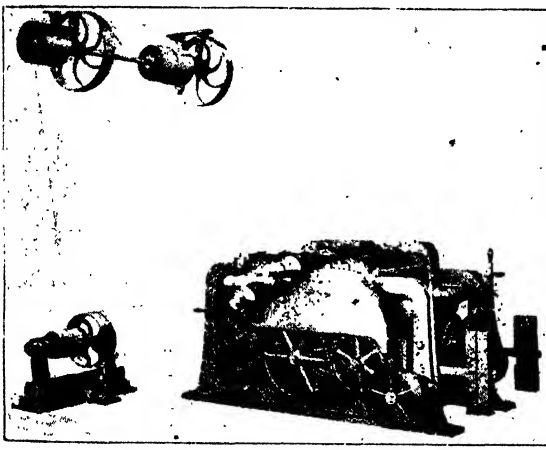
that they give a little, and so accommodate uneven timber. The upper cylinder comes into operation first, so that the top face of the board presents a true surface to the subsequent rolls which keep it in contact with the lower cutter cylinder.

The capabilities of the panel planer are greatly increased by fitting side spindles [59]—Ransome—set vertically, and carrying cutter blocks at the top to work the edges of boards, etc., at the same time the surfaces are planed. By putting on suitable cutters, tonguing and grooving and moulding can be done. The side spindles are adjusted vertically and laterally.

Four-cutter Planers. The most complete types of machines are those which work all four faces of the wood simultaneously—the *four-cutter* machines. These have the highest output, and a very good finish is imparted provided proper care is taken in working the machine. They embody a *fixed* knife in addition to revolving cutters, this knife giving a very smooth surface to the work. But as good results can be obtained only by feeding the stuff past the knife at a high rate, and as this demands great power, it is more convenient to use a fixed knife on one side of the wood only—the under side—working the other side and the edges with rotating cutters. In 61, which gives side



57. PANEL PLANER WITH SIDE SPINDLES



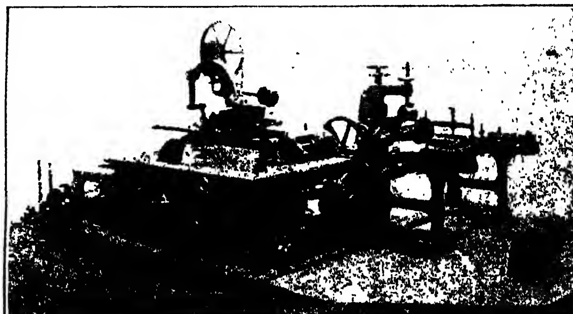
58. WHITNEY DOUBLE SURFACER

elevation and end view of a 16 in. by 6 in. four-cutter machine for heavy work—A. Ransome & Co., Ltd.—the respective positions of the cutters are indicated at A, B, C and D, these letters being put on the timber for clearness. The timber is fed in at the right-hand end, first by two pairs of large serrated rollers, driven by gearing, and weighted through balanced levers. On arriving at A, the wood is attacked by the bottom cutter block there, which trues the under side. Passing on to B, the fixed knife is encountered, this finishing the under side. A series of pressure rollers are placed above A and B, each roller being provided with an independent weight, so that any irregularity is accommodated. Other large feeding rollers at the centre of the machine continue to carry the timber on and past vertical cutter blocks at C, which plane or mould the edges, weighted pressure rollers keeping the wood down at this point. Finally another horizontal adze block is met at D, finishing the top face. By means of the hand wheel E, the operator can raise or lower the whole of the top feed rollers at once for timber of different thicknesses.

The fixed knife at B is rapidly dulled by its work, notwithstanding that the block at A has roughed off the outside of the timber, and it is therefore fixed in a removable drawer, that can be pulled out and changed rapidly. The rates of feed are variable, ranging from 110 to 115 ft. per minute for soft wood. It may be mentioned that the fixed knife cannot be applied successfully to cutting hard woods. It is set angularly across the machine to give a shearing cut, and the pressure rollers above it are placed to correspond. An extra cutter spindle is sometimes added at the delivery end for *sticking* a light beading on the top of the plank or board. A *shavings cutter* is a useful adjunct to a machine having a fixed knife; it comprises a hopper containing revolving cutters, which cut up the long shavings into short portions, that can be readily sucked up by a pneumatic exhausting system.

Rapid Planers. The *lightning* or *rapid* planers are a special class, using a fixed knife only. The work is carried over it by a large roller covered with indiarubber, and the rate of feed is very high. The class of planing done is that on box boards, lap boards, blind laths, which are light, and which require only a thin shaving off to produce a highly finished surface.

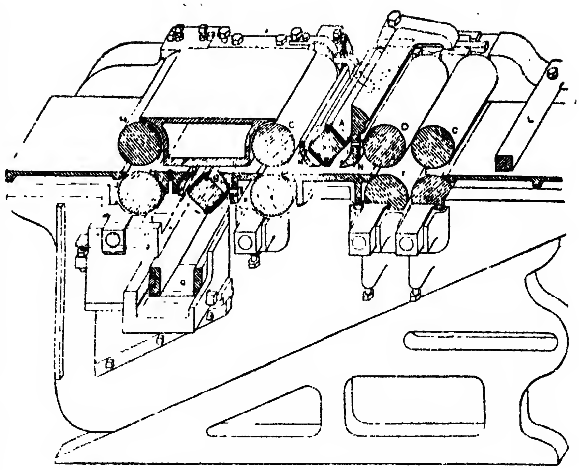
Four-cutter Moulders. Four-cutter machines, designed for producing mouldings only,



59. GENERAL JOINER

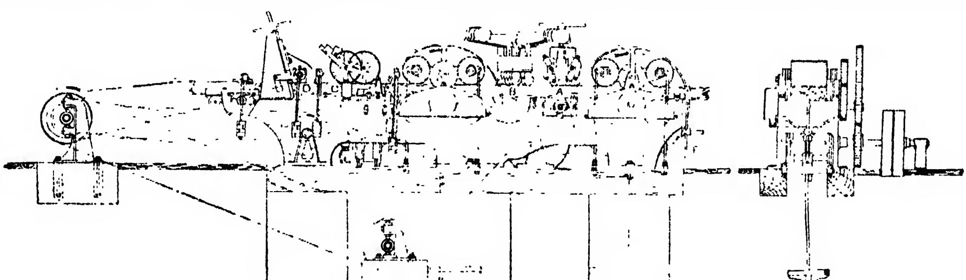
resemble the planers in many respects; but the fixed knife is not used. A good idea of a moulder can be obtained from the drawing [63]—John Sutcliffe & Son, Ltd., Halifax—showing a 16 in. by 4 in. machine in elevation, plan, and end view. The cutter block spindles are at A, B, and C for bottom, edges, and top respectively. The fluted feed rollers, situated under covers at D, can be driven at any of six different rates, from 18 ft. to 70 ft. per minute of feed, the variations being produced by sliding spur gears, as seen. The wood is held firmly to the cutters by weighted *pressures,* which can be adjusted to suit requirements. Combined planing and moulding machines are employed for either class of work, as desired.

The spindles of these planing and moulding machines run at a very high rate, ranging from 4,500 to 5,500 revolutions per minute, and the cutters must be very accurately balanced in order to produce true work and to avoid damage to the machine through irregular running. The bearings must also be good, with ample surface, and making a close fit without shake, which is fatal to accurate results in planing or moulding.

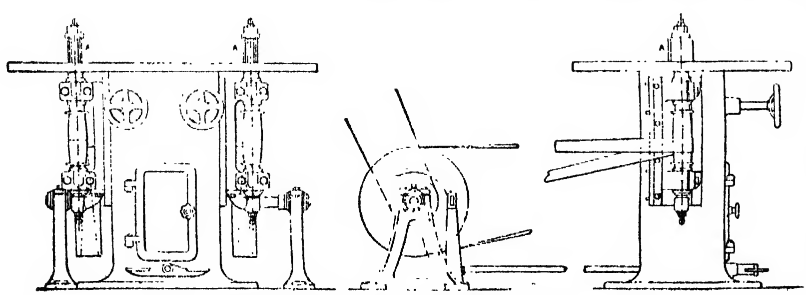


60. SECTIONAL VIEW OF DOUBLE SURFACER
A. Upper cylinder B. Lower cylinder C. First upper infeed roll D. Second upper infeed roll E. First lower infeed roll F. Second lower infeed roll G. Third upper feed roll H. Fourth upper and outfeed roll J. Fourth lower and outfeed roll K. Third lower feed roll L. Guard M. Back pressure bar for upper cylinder N. Front pressure bar for upper cylinder O. Back pressure bar for lower cylinder P. Lower front pressure bar Q. Lower cylinder slide

Vertical Shaper. The *vertical* spindle moulding machine, or *shaper,* is a very different type from the foregoing. It has either one or two spindles, projecting up through a table, on which the work is laid. The spindle carries a moulding iron, and as the work is traversed past, it cuts the surface into a form corresponding with that of the iron. A fence guides the wood in a straight line. Figure 62 shows a double-spindle machine by Messrs. Thomas White & Sons, Paisley, from which it is seen that the spindles AA have long pulleys driven by half-twist belts from the countershaft. Each headstock carrying its spindle is adjustable up and down in slides, the adjustment being obtainable by turning the hand wheels at the front. The treadle in front, near the ground, enables the operator to start and stop the machine by shipping the belt on the fast and loose pulleys at the countershaft. Concentric rings are fitted into the table around the spindles, to allow of putting on differently-sized cutters. The object in having two spindles is to enable curvilinear work to be done expeditiously, by using one or other of the spindles, which revolve in opposite directions, according to the way which the grain runs. Otherwise clean work cannot be ensured. If the machine has only one spindle, that has to be reversed, and a different cutter

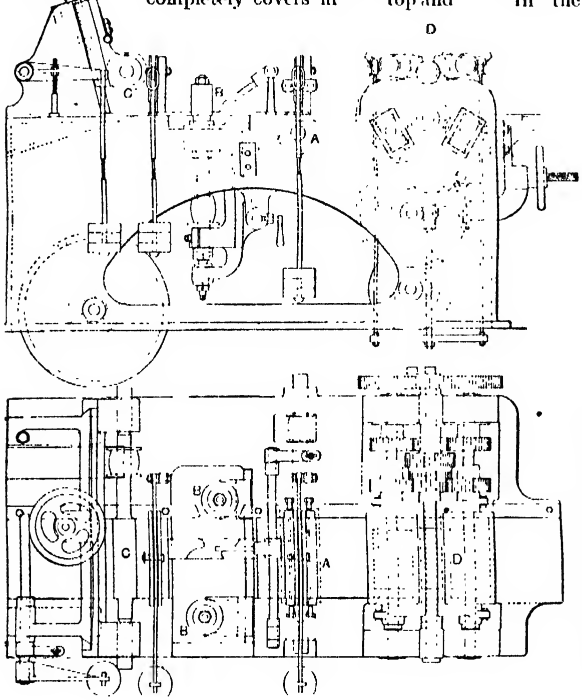


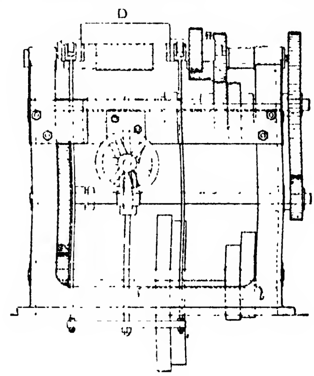
61. FOUR-CUTTER PLANING MACHINE



62. VERTICAL DOUBLE SPINDLE MOULDING MACHINE

block also put on, or else double-edged cutters are used. The working of curves is effected by using a template of the correct outline, placed beneath the moulding, and bearing against a ring encircling the shaper spindle. The template can often be dispensed with and the moulding alone brought into contact with the guide-ring, or collar. It is best to fit a guard over the revolving cutter, as a protection to the operator. A cage made of strips, or of netting, completely covers in top and





63. FOUR-CUTTER MOULDING MACHINE

the sides as far down as the work will allow. There is then no risk of the workman getting his fingers caught through the wood slipping.

A special attachment for cutting dovetails is often fitted to these shapers, comprising a clamp, which holds the wood vertically, and presents it to the dovetail cutter on the end of the spindle. The pitch of the dovetails is determined by a template plate, having notches which lock the clamp at definite positions while the cutter is at work.

Another class of moulding machine, which possesses a greater range than the foregoing, is made with an overhanging arm supporting a vertical spindle, below which a large table is located. In this design the work can be passed *under* the tool, and operations be done on the central portions of a board or panel, such as raising or recessing various patterns, cutting grooves or trenches, in string boards for stairs and shelves. The table can be moved about freely to carry the work, and is fitted with fences.

In the most complete machines a vertical shaping spindle is included, projecting up through the table, by which ordinary mouldings can be worked. The term *variety* moulding machine is commonly applied to this class. In some cases the overhanging arm is fitted with a hinge at the back in order that it may be turned over out of the way when not in use. A very useful application of the vertical spindle is that of preparing core-boxes for patterns, the recessing being done accurately and much more rapidly than by hand methods.

General Joiner. The *general joiner*, or *universal* joiner, or *complete* joiner is a combination machine of great utility in situations where a number of separate machines cannot be installed. It combines [59]—Thomas Robinson & Son, Ltd., Rochdale—a circular saw, with rising and falling spindle, with which sawing, tonguing, grooving and rebating can be done, a band-saw apparatus with 24-in. pulleys, a four-side planing and moulding apparatus, taking timber up to 12 in. by 4 in., a vertical spindle for circular moulding, and a tenoning apparatus. Boring may be done also by attaching a bit to the tenoning spindle. All the motions are derived from pulleys at the left-hand side.

Continued

SHIP MANAGEMENT continued from page 6414

THE SCIENCE OF NAVIGATION

The Instruments Used. The Principles of Navigation and the Several Methods of Determining Latitude and Longitude

By J. P. LORD

THE instruments commonly employed by the navigator, and which are regarded as essential, are the *mariner's compass*, the *chronometer*, the *sextant*, the *azimuth compass*, and a set of charts. To these must be added a Nautical Almanac for the current year, a set of tables, preferably those by Norie, a complete set of azimuth tables, by Burdwood & Davis, a set of Admiralty tide tables and other papers issued by the Hydrographical Department for the guidance of mariners, a Napier's diagram, parallel rulers, stationery, etc.

Instruments. The mariner's compass is a circular card, the edge of which is divided into 32 points, half points and quarter points and also into 360 degrees. Fixed to this card below is one or more small steel bars, magnetised, with the north pole of the magnet to the North point on the card. The whole is then balanced on a sharp point and enclosed in a copper bowl, which is swung on gimbals to keep it nearly horizontal when the ship is pitching and rolling.

The azimuth compass is similar to the mariner's compass, but is constructed with greater accuracy. It is fitted with sight vanes for taking bearings of distant objects, and is placed on the ship in a position which permits it to sweep the horizon.

The chronometer is a clock as nearly perfect as the weakness of man will permit. It is used to show the time at Greenwich at any given moment. It is arranged not to stop while being wound, and is adjusted so as to gain but a fraction or lose but a fraction of a second a day.

The sextant is used for taking vertical and horizontal angles. Its main construction will have been described in the articles on surveying, but the sailor must know how to adjust it himself. Essentially it consists of a graduated arc bearing a telescope and a fixed glass called the *horizon glass*. Attached to the apex of the sector is an arm which bears an index and vernier for reading the angle on the arc, and which also carries another glass, known as the index glass. The index arm and glass are movable, but can be clamped at any point. When an object is looked at through the telescope, with the index of the arm placed to zero, if the instrument is in adjustment the object appears normal.

The adjustments of the sextant are three in number, and are as follow:

(1) To set the index glass perpendicular to the plane of the instrument. Set the index about the middle of the arc, hold the sextant face up, and arc from you, and look into the index glass to see if the true and reflected arcs are in one unbroken line. If they are, the instrument is correct, but if not, the screws at the back of the index glass frame must be turned till the arc forms one clear line.

(2) To set the horizon glass perpendicular to the plane of the sextant. Set the index to 0. Hold the sextant nearly horizontal and look through the telescope and horizon glass at the horizon. If the glass is perpendicular to the plane of the instrument, then the true and reflected parts of the horizon are in one straight line. If the line is broken, then the screw at the back of the horizon glass must be turned till the line is unbroken.

(3) To set the horizon glass parallel to the index glass. Set the index to zero, hold sextant vertically, and look through the telescope at the horizon. If the true and reflected parts of the horizon are in one straight line the adjustment is perfect, but if not, the horizon glass must be moved by its screw till the line is unbroken. If there is no screw for making this adjustment, then the index error of the instrument must be taken. Set the index near 0, hold the sextant vertically, and look through telescope and horizon glass at the horizon. If the line is not perfect, move the tangent screw of the index till the line is unbroken, then read the graduations on the arc, the reading being the index error to be added to all computations if it is off the arc, and to be subtracted if it is on the arc.

Index Error by the Sun. More advanced mariners will obtain their index error from the sun by the following method:

Place the index to about 30′ on the arc. Hold sextant vertically and look through horizon glass and telescope at the sun. On doing so two suns will appear. Bring them edge to edge by the tangent screw, read the arc and note down the reading. Now place index at 30′ off the arc and do the same thing, and write down the second reading. Subtract the smaller reading from the greater, and divide the remainder by two.

The result is the index error. To prove that you are accurate in your observations, add the two readings together and divide by 4. The answer should be the sun's semi-diameter for the day, and should agree with the figures given in the Nautical Almanac.

Compass Corrections. Iron ships are liable to cause the compass to vary, the error or difference from the correct magnetic points being called the *deviation*. The errors set up are of varying kinds, some being due to the fore-and-aft iron, some to the vertical, and some to the transverse iron, while again every iron vessel has a sub-permanent magnetism set up during her building. All these can be corrected for any one spot, but correction for the whole of the globe is outside our power. The modes of adjustment are as follow:

To correct for semicircular deviation caused by ship's own magnetism. See that vessel is upright. Put her head correct magnetic N or S, and place a magnet either before or abaft the compass, parallel to the thwartship line, with its centre on the fore-and-aft line, and the red end on the same side as that to which the compass North is drawn. Move the magnet to or from the compass till the compass needle points correct magnetic N. Swing ship correct E or W, and place magnet either on port or starboard side of compass, parallel to the fore-and-aft line, with its centre on the thwartship line and red end on side to which North point of compass needle is drawn. Move magnet as before till needle points correctly and ship's head is correct magnetic E or W by compass. The deviation from ship's sub-permanent magnetism is then corrected.

To correct for semicircular deviation caused by induced magnetism in vertical soft iron. Put ship's head due magnetic E or W, and place a Flinders bar or bar of soft iron vertically on the fore-and-aft line, before the compass if the north point is drawn aft, and behind it if the N end of compass is drawn forward. Move the bar to and from the compass till ship's head is correct magnetic E or W by the compass.

To correct for quadrantal deviation caused by induced magnetism in horizontal soft iron. Put ship's head on one of the quadrantal points, NE or SW correct magnetic, for instance, and place soft iron balls on each side of the compass in a line exactly at right angles to the fore-and-aft midship line of the ship. Move the correctors to and from the compass till the ship's head and compass agree. This correction does not vary by change of position on the earth's surface, and so ship's standard compasses are usually found with ball correctors in position.

Heeling error is corrected by placing a magnet vertical to the ship's deck beneath the centre of the compass, when the latter is at rest and the ship upright.

On every ship are to be found tables of the deviation of the compass on the principal points,

and these are continually being checked by observations. The deviation tables so constructed are in daily use on every vessel when determining the ship's position.

Rule of Thumb. The art of navigation as practised at sea is really simply the application of a number of arbitrary rules, deduced by mathematicians, and the rules must be learnt by heart for very few sailors could possibly tell you how the rules were obtained, or how their accuracy can be proved. Every sailor who becomes an officer must be able to use logarithms. That is to say he must be able in the tables to find the logarithm of any number or angle and add them together or subtract them as the case may be, and then again from the tables to find what number or angle the logarithm is the logarithm of. He has to make use of sines, cosines, secants, and other trigonometrical functions without knowing what they are. He merely depends on his tables. He will find the logarithms of common numbers on Table 24 in "Norie's Tables," or in Table 64 in "Raper's Tables." Throughout this article we shall assume that the student has access to "Norie's Tables," as they are the ones most generally used.

The first process a navigator must learn is how to find his position by dead reckoning—that is to say, by taking the courses on which the ship has sailed, and the number of miles she has travelled over each, making allowances for deviation and variation of the compass on courses steered and for currents and leeway. This is known as the *day's work*.

The Day's Work. The *day's work* starts with a bearing or departure course. When a ship leaves the land this is usually a point ashore; when as sea it is the position on the previous day, or when last sights were taken.

The Bearing or Departure Course. Take the given bearing and reverse it; consider the number of points it is from North or South and turn them into degrees. Then allow the deviation for the direction of the ship's head. Easterly deviation is allowed to the right hand, and westerly deviation to the left hand. After this allow the variation—easterly variation to the right hand, and westerly to the left. The result is rega ' ' a true course and is entered as such in the traverse table with the distance of the object from which the bearing was taken. After the first day this need not be done, for the course the ship is on is the departure course for the day. The courses on which a vessel sails each hour are entered in the log book, with the direction of the wind and the leeway made. From the deviation table of the ship the deviation on each course is entered in the log, and from the Admiralty chart the variation of the region is also entered, care being taken to enter any change in the variation. This is done by the officer of the watch, and at noon nearest after sailing the *day's work* is continued.

Take the first course sailed and correct it for leeway—if on the port tack to the right hand; if on the starboard tack to the left hand. After this allow the deviation and variation as above for the departure course, and the result is the *true course* sailed. If it is over 90° subtract it from 180 and change N into S or S into N, keeping it E if originally E or W if W.

Do the same with each of the different courses sailed. Then take the *current course* and allow only the variation on it, for the set of the current is usually given correct magnetic and so is not affected by deviation.

When all these courses are corrected enter them one under another in the traverse table. Then take the distances sailed over each course and enter it in distance column of traverse table. Next from Norie Table 2 take out the D. lat. and dep. for each course and distance sailed and place them in their respective columns, and thus the traverse table is completed.

Add up N column and S column and subtract the less from the greater; the result is the D. lat. of the same name as the greater. Add up the E column and then the W column and subtract the less from the greater; the result is the dep. of the same name as the greater. *Dep.* stands for departure, *D. lat.* for difference of latitude, and *D. long.* for difference of longitude, for the meaning of which see dictionary following this article.

Now find latitude in. Write down *Lat. left*, that is lat. of point of land, or lat. of ship's position when last day's work was made up, and below it place the D. lat., previously bringing it to degrees if necessary. If D. lat. and lat. left are same name, add them together; if contrary names, subtract them. The sum or the remainder is the lat. in, of the same name as the greater.

Now find Middle lat. (Mid. lat.). Bring down lat. left below the lat. in, and if of same name, add; if contrary names, subtract less from greater, and divide sum or remainder by 2. This gives Mid. lat.

Then find D. long. Turn to Table 2 (Norie), and with Mid. lat. as a course, and with Dep. in D. lat. column, the number in the Dist. column is the D. long. of the same name as the Dep. If the Dep. is very large and cannot be found in D. lat. column, divide Dep. by 2, proceed as above, and when a result is obtained multiply it by 2 to give D. long.

Or find D. long. by parallel sailing. Add together the log secant of the Mid. lat. and the log of the Dep.; the result is the log of the D. long. This is the most accurate method, and should always be used in high latitudes.

To find the long. in, write down long. left, and below it place D. long.; if of same name, add; if of

Corrected Courses	H	Courses	K	$\frac{1}{10}$	Winds	L	Deviation	Remarks
S 10° 0′ W	1	S S E	7	2	S W	1	3° 24 E	A point of land lat 37° 30 S and long 178° 30 E, bore N 10° E by compass, distant 24 miles, ship's head S S E Deviation 3° 24 E
24° 44 W {Dev & var	2		6	6				
	3		8	7				
S 5 44 E = S 6° E	4		7	3				
	5	E	5	8	S E by S	½	10° 46 E	
S 33° 45 E	6		7	3				
24° 44 W	7		8	0				
	8		8	8				
S 58° 29 E	9	N E ½ E	7	3	Ditto	0	6° 6 E	
	10		8	7				
N 84° 22 E	11		8	1				Variation of compass 28° 8′ W
17 24 W {Dev & var	12		7	0				
	1	S by E	6	9	S W	1½	1° 02 E	
N 66° 58 E	2		2	2				
	3		7	0				
S 30° 27 E	4		6	9				
20° 4 W {Dev & var	5	S E	5	1	S S W	1	6° 18 E	
	6		7	4				
S 50° 31 E	7		8	0				
	8		7	5				
S 22° 10 E	9	N N E	6	7	N W ½ W	1½	6° 20 E	
26° 26 W {Var & dev	10		8					A current set the ship N N W Correct magnetic, 24 miles during the day
	11		7	2				
N 48° 36 E	12		7	1				

Corrected Courses	Courses	Dist	N	S	E	W
S 8 17 E	S 6° E	24		23 9	2 6	
21 50 W {Dev & var	S 58° E	28		14 6	23 7	
	N 67° E	24	10 0		22 4	
S 78° 5 E	N 31° E	30	25 7		15 5	
	S 59° E	28		14 4	24 1	
N 39° 22 E	S 78° E	31		6 4	30 3	
24 08 W {Dev & Var	N 15° E	29	28 0		7 5	
	N 51 W	24	15 1			18 7
N 15 14 E			78 7	63 5	126 4	18 7
Current Course			63 5		18 7	
N 22 30 W		N	15 2	E	107 7	
28 8 W Var						
N 50 38 W						

Lat left 37° 30′ S	Log Dep = 2 032216
D lat 16 N	Log Sec M lat = 10 099760
Lat in 37° 14 S	Log D Long = 2 131976 D. Long. = 2° 18′ E.
Lat left 37° 30 S	Long left 178° 30′ E
Mid lat 2)74° 44	D Long 2° 18 E
37° 22	Long in 180° 48 E = 179° 12′ W
Course N 80° E	Distance 111 miles

Explanation: *Column* to extreme left is used for ascertaining the corrected course.

Upper table is the extract from the ship's log. H is hours, Courses are compass courses. K and $\frac{1}{10}$ are knots and fractions sailed, L gives leeway.

Lower table is traverse table made out as given in the text.

contrary names, subtract. The sum or remainder is the long. in of the same name as the greater. If longitude is greater than 180, subtract from 360, and call remainder Long. in of an opposite name to Long. left.

You have now found your ship's position, having her latitude in and longitude in, and on the chart you can find how many miles she has made good, but it is better to do so as follows. The course is on the top of the page when D. lat. in traverse table is greater than Dep., and on the bottom when it is less. In Table 2 look for a page on which your D. lat. and Dep. correspond, or very nearly so, with those printed. The distance will be found alongside, and the course on the top or bottom of the page as explained. You thus have course and distance, which can be used if you like as a true departure course for next day. An example of a day's work, with the entries in the log, is shown on the previous page.

Latitude by the Sun at Noon. This is an everyday operation at sea, provided the sun is visible at midday. To obtain the altitude the sextant is used. The observer stands facing the sun at about, but rather before, the estimated noon. He holds the sextant vertically, and looks through the telescope and horizon glass at the horizon. Then he moves the arm of the index till he sees the reflection of the sun just touch the horizon. Several times he will have to move the glass, for the sun will seem to shift its position. At last he will hit the moment when the sun seems just stationary on the horizon, and then starts to dart away. At that instant he clamps the index. It is noon. A reading of the arc will then give the observed altitude of the sun.

Now find Greenwich time. Write down year, month, and day, P. hrs., P. min., P. secs. Turn the longitude into time by multiplying by 4 and dividing by 60, and place it below 0h., 0m., 0s. If West long., add; if East, subtract. Result is Greenwich apparent time (or G.A.T.).

To Find Correct Declination. This enters into very many problems and the student must gain great facility in working it. Take out decl. for Greenwich day and variation for one hour, which multiply by the hours and tenths of an hour in the G.A.T., paying attention to the proper making of the decimal point, divide by 60 if necessary, and result is the correction of the declination. If the declination is increasing, as seen from the Nautical Almanac from which it was taken, add the correction to the day declination; if decreasing, subtract the correction. The result is the correct declination.

To Find the True Altitude. Write down the altitude you have observed, and correct it as follows: Apply the index error of your sextant, adding or subtracting according to your determined rule. Look out the "dip" for the height your eye was from the sea in Table 5 (Norie), and always subtract this. Look out "Refraction" in Table 4 (Norie), and always subtract this. Look out "Semi-diameter of sun" for Greenwich day on page 11 of Nautical Almanac. If lower limb was observed, add; if upper, subtract. Look out "Correction for parallax" in Table 6, and add this always. The result is the true altitude of the sun.

Next find "Zenith distance," or Z.D. Subtract true altitude from 90, and mark remainder of opposite name to "sun's bearing"—that is, Z.D. Now find latitude. Below Z.D. put corrected decl. If Z.D. and decl. are of same name, add them; if different names, subtract. The sum or remainder is the latitude, which is always of the same name as the greater of the Z.D. and declination. We give below an example of this method for the student to examine.

Example. On September 22nd, 1898, in Long. 115° 30′ W. the observed altitude of sun's lower limb at noon was 62° 10′ 25″, bearing N Index error 2′ to subtract; height of eye 17 ft. Wanted latitude.

Sept 22d	0h 0 0″	Long	115° 30 W	Observed Alt.	62° 10′ 25″ N.
	7h 42		4′	Index error	2′
Sept 22d	7h 42 0″ G.A.T		60)462° 0′		62° 8′ 25″
			7° 42′	Dip	4′ 2″
					62° 4′ 23″
				Refr	30″
					62° 3′ 53″
Decl for 22d	= N 0° 12′ 22″		58″ 46	Semidiam.	15′ 58″
H Diff	7 30″		77		62° 19′ 51″
Corr Decl.	4 52″		60)450 066	Parallax	4″
			7 30″	True alt	62° 19′ 55″
			90° 0′ 0″		
			62° 19′ 55″ N.		
		Zenith Dist.	27° 40′ 5″ N.		
		Corr. Decl	4′ 52″ N.		
			27° 35′ 13″ S Latitude.		

Parallel Sailing. Three factors enter into problems in parallel sailing—namely: (1) The distance between two meridians on a given parallel of latitude, which is Dep. or *meridian distance*; (2) the latitude of that parallel, which is latitude; and (3) the distance between the meridians on the equator or D. long. Any two of these being known, the third can be found by the following formulæ:

Example. A ship sails due east 206 miles from Sandy Hook Light, in latitude 40° 28′ N, Long. 71° 50′ W. What Longitude does she arrive at?

Log departure	..	2·313867
Log sec. Lat. ..	..	10·118739
Log D. Long.	..	2·432606
D. Long	..	4° 30′E.

Long left	73° 50′W.
D. Long	4° 30′E.
Long in is	69° 20′W.

Log D. long. equals Log Dep. added to Log sec lat.

Log Dep. equals Log D. long. added to Log cos lat.

Log cos lat. equals Log D. long. subtracted from Log Dep.

The logarithms of all these factors can be found in the tables, and when an answer is found the number of degrees and hour corresponding to that log can also be found in the same tables.

Mercator's Sailing. Mercator's charts have the meridians of longitude parallel to one another, and the distance between the parallels of latitude varies proportionally to the opening out of the meridians. The only problem in this species of sailing commonly used is to find the course and distance between two places whose latitude and longitude are known.

The rules for working this problem are as follow:

Find D. lat. by subtracting the less of the two latitudes from the greater if of the same name, and adding them both if of different names. Multiply the degrees in the answer by 60 and add in the miles. The result is D. lat.

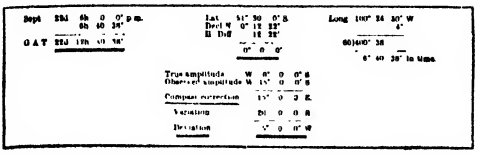
Find meridional difference of latitude, or M.D. lat. From Table 3 (Norie), take out the meridional parts for the two latitudes. Latitudes of the same name subtract; of different names add. Result is the M.D. lat.

Find the D. long. Longitudes of same name subtract; of different names add. Bring result into miles and call it D. long.

TO FIND COURSE. From Log D. long., with index increased by 10, subtract log of M.D. lat. Answer is Log tan of true course. This must be taken out very exactly.

TO FIND DISTANCE. To Log sec of true course, taken out to seconds, add Log D. lat. Result, subtracting 10 from index of log, is the log of the distance. Great care must be used in naming the course.

Example: On September 22nd, 1898, at 6h. 0m. p.m. apparent time on ship, in lat. 50° 30′ S., long. 100° 24′ 30″ W. The sun set by compass S. 75° W. Required true amplitude and error of compass. If variation is 20° E., what is deviation for the then position of ship's head?



True amplitude	W. 0°	0′	0″	S.
Observed amplitude	W. 15	0′	0″	S.
Compass correction	15°	0′	0″	E.
Variation	20°	0′	0″	E.
Deviation	5°	0′	0″	W.

To Find the Compass Course. The compass course is the course shown by the ship's compass when the vessel is really sailing along a true course. Take the true course and below it place the variation. If variation is west, allow it to the right; if east, allow it to the left. Result is magnetic course. Below magnetic course place deviation, and if it is west, allow it to the right; if east, allow it to the left. The result is the compass course, or the course to be given to the helmsman.

Amplitudes. The principal object of taking an amplitude is to obtain the error of the compass. The exact bearing of a heavenly body either just as it is rising or setting is taken by the compass and written down as the observed amplitude. Now find Greenwich apparent time (or G.A.T.) as in the day's work, only, instead of hours, minutes and seconds being PO, O, O, they will be the actual time. If a.m., add 12 hours to the time and take off one day of the date. Next find true declination as before. To find the true amplitude to log sine or sin of true Dec., add log sec of lat.; the sum, rejecting 10 from index, is log sin of true amplitude. If a.m., name it E; if p.m., name it W. If Dec. is N, name it N; if S, name it S.

Having got the true amplitude, compare it with the observed amplitude, and then the difference between them is the error of the compass. The variation for the latitude is known from the chart, when the error has been corrected for variation, and what remains is the deviation.

Azimuth. To find true azimuth, the navigator must be equipped with azimuth tables, and have access to a good azimuth compass. By looking through the sight vanes of the azimuth compass, he takes the bearing or the object, be it sun or star, and reads on the card the observed azimuth. At the same time he takes the time on ship. Next he finds the Greenwich mean time (or G.M.T.) as follows. Write down year, month, day, hours, minutes, and seconds of ship time, and if it is a.m. at ship add 12 hours, and take off a day of date. Turn longitude into time, and if it is W., add; if E., subtract. Result is G.M.T. Find the equation of time from page 11 of the month in Nautical Almanac for the Greenwich day of the G.M.T., and also the variation in one hour of the same day from page 1 of the same. Multiply the variation in 1 hour by hours and tenths in G.M.T., and add result to the equation if it is decreasing. This gives true equation. Find the true declination as before.

To the time at ship apply the corrected equation of time. The result is the apparent time at ship.

Now take the tables of azimuths and enter them with the latitude, and be careful to notice if the latitude and Dec. are of the same or of different names. Then opposite apparent time at ship will be found true azimuth. This is named the same as the latitude—E in morning and W in afternoon. This compared with observed azimuth will give the compass connection, and thence the deviation, the variation being known.

Longitude by Chronometer. The latitude is generally taken daily at noon, whenever practicable, and to get the latitude at the time sights are taken for longitude by chronometer. The navigator must find the D. lat. as in the day's work, up to the time he is going to take sights. If a.m. change the name of the D. lat., and if p.m. change the name of the dep., which he will also have to take out. After which get latitude in and D. long., as in day's work. Now take the altitude of the sun, just as if it was noon, but the lower limb need only to be brought to touch the horizon, and the index arm clamped. At that moment the time by the chronometer is noted. The arc of the sextant is read, and the reading noted down as observed altitude. The chronometer time is also noted down. The navigator first turns his attention to the chronometer time. He turns this into astronomical time and applies the error of the chronometer, either gaining or losing as the case may be. Now from observed altitude he obtains true altitude as in lat. at noon, and gets polar distance and equation of time from the tables. Next write down the true altitude, below it place the lat. and polar distance. Add the three together and divide by 2. The result is called *half sum*. From half sum subtract true altitude. The result is remainder. From Table 25 take out the following logs to seconds: Log sec of latitude, log cosec of polar distance, log cos of half sum and log sine of remainder. Add the four logs together and cast out the tens in the index. Look out the log in Table 31, and it will be found to be the hour angle, or time from the nearest noon.

Now if it is a.m. on ship, subtract hour angle from 24 and deduct a day from the date; if p.m., put hour angle as time with same date as on ship. This gives us apparent time on ship.

Find mean time on ship. Below apparent time on ship place corrected equation of time and apply it as indicated in almanac, page 1 of month. The result is mean time on ship.

Now find longitude. Below mean time on ship place mean time at Greenwich, putting down days as well as hours. Subtract the less from the greater. The remainder turned into degrees is the longitude of the ship at the moment the sight was taken. If the Greenwich time is less than ship time, longitude is E., if larger longitude is W.

Longitude by Chronometer and Azimuth Combined. This is not a very popular problem with officers, but is required by the Board of Trade for examination purposes, so we shall indicate how it is obtained. Proceed as in longitude by chronometer till the true altitude and polar distance have been found. Find half sum, and the remainder, which call chronometer remainder. Obtain sun's hour angle from Table 31 as before, and thus get longitude. Now subtract the polar distance from half sum, or half sum from polar distance, and call *azimuth remainder*. Add together the log sec of altitude, log sec of latitude, log cos of half sum, and log cos of azimuth remainder; cast off 20 from the sum of the indices and divide the rest of the sum of the logs by 2. Result is the log sine of half the true azimuth, which take out from Table 25 to nearest half mile,

and multiply by 2. The result is the true azimuth. On the left hand of the azimuth put N. if latitude is S and S if latitude is N. On the right hand put E if a.m., and W if p.m. on ship.

Example: On September 1st, 1898, at about 0h. 30m. a.m., mean time in lat. at noon 47° 20′ N., and long. by account 166° 14′ E., the observed altitude of sun's lower limb was 39° 49′ 5″, bearing by compass S.E. Height of eye 17 ft. Time by chronometer 10h. 15m. 20 sec., which was 6m. 50 sec. slow on mean noon at Greenwich on May 1st, and losing 3·5 seconds daily, the ship having made 30 miles on a true south course between time of observation and noon. Required longitude at noon, and supposing variation to be 5° E., required true azimuth and deviation for direction of ship's head.

30 miles south course	Lat. at noon	47° 20′ N.
	Diff. of Lat.	30′ N.
	Lat. at sights	47° 50′ N.

30 miles S. course Lat. at noon 47° 20′ N
Diff. of Lat. 30′ N
Lat. at sights 47° 50′ N

Time by chronometer Augt. 31d. 10h. 15m. 20s.
Error 6 50
Accumulated rate at 3·5 secs. per day 8

G M T August Augt. 31d. 10h. 29 18

Decl. N 8° 33′ 0″
H D 0 28″

N 8° 28′ 32″
90°

Polar dist. 81° 36′ 28″

Obs. Alt. 39° 49′ 5″
Dip 4 2
Refr. 1 9

39° 43′ 54″
Semidiam. 15 52

39° 59′ 46″
Parallax 7

True alt. 39° 59′ 53″

Eq. of Time 0 0 + App. Time

Lat.	47° 50′ 0″ N	Secant	10·173090	Sec	10·173090
Alt.	39° 59′ 53″			Sec	10·115746
Polar Dist.	81° 36′ 28″	Cosec	10·004675		
	2)169° 26′ 21″				
				Cosine	8·963043
Half sum	84° 43′ 10″	Cosine	8·963043	Cos	9·999381
Alt.	39° 59′ 53″	Sine	9·847363		2)19·252140
Remainder	44° 43′ 17″		38·988171		9·626070 ½ Azimuth log
Half sum	84° 43′ 10″				
Polar dist.	81° 36′ 28″				
As Merc.	3° 6′ 42″				

31d. 21h. 34 26 A T S
0 0 Eq. of Time

31d. 21h. 34 26 Mean T S
31d. 10h. 29 18 M T Greenwich

11h. 5′ 8″ Long. in Time E.
60

4)665 8

166° 17′ E. Longitude.

22° 30′ 0″ ½ Azimuth
S 45° 0′ 0″ E Az. True
S 45° 0′ 0″ E Az. Obs.

5° 0′ 0″ W Compass error
5° 0′ 0″ E Variation

W 10° 0′ 0″ = Deviation

Charts and their Uses. Charts are of two recognised kinds—namely *true charts* and *magnetic charts*, the former having the compass printed on the chart showing "true North," while the latter shows magnetic North. To find the course to be steered between two points, join them by a faint line, and draw a faint line parallel to this through the centre of the compass. If the chart is a true one, you must look on it for the variation nearest to the marked course, and apply this to the course shown on the compass, W variation to the right, and E to the left. This will give the magnetic course. To this apply the deviation of the ship's compass on that particular course, and the answer will be the compass course to be steered. To obtain the distance between the two points measure the line and transfer the measurement to the graduated meridian, when it can be read off at once.

Again, with a ship on a compass course, to obtain the true bearings of observed objects or points on the chart the compass bearing must be corrected by applying the deviation and variation in order to obtain their true bearings. These true bearings are laid off on the chart compass if a true chart, or the magnetic bearings laid off if the chart is magnetic, and where lines parallel to these bearings but passing through the observed points intersect will be the position of the ship. The longitude and latitude of that position can be read off on the border of the chart.

A third use of the chart is to find the position of the ship by two observations of the bearings of the same object. The compass bearings must both be turned into magnetic or true bearings according to the sort of chart and then lay these bearings off from the point, and let the fine lines cut the line of course as marked on the map. Take distance ship covered between bearings, and from point where first bearing cuts line of course measure off that distance. If the ship were actually travelling along that course, the distance would correspond with the line of second bearing; but she is not, so through the point where the distance reaches to draw a line parallel to the first line of bearing and where this cuts the second line of bearing will be the position of the ship.

The small figures placed on the chart indicate the depth of water at low water of ordinary spring tides: the Roman numerals show the time of high water at full and change of moon.

Tides. The time of high water at any place can be taken out from the Admiralty Tide Tables, but if these are not available, to the time of high water at full or change add 49 minutes for every day elapsed since full or change. The result is time of p.m. high water approximately.

To Correct Cast of Lead. From Admiralty Tide Tables find times of high water on the day at the place you are nearing. Take the tide nearest to the time you are sounding. Find the height constant by subtracting the spring rise of the port you select from the Port of Reference spring rise, as given in the Admiralty tables. This you add to the reference port rise if the height at selected port is more than that of port of reference, or subtract if less. Thus you get height of high water at your nearest port, and from this subtract the half spring rise there. The result is the height of high water above half tide. Now double the time from high water, and if over 6 hours subtract from 12. Consider this a course. Bring height of high water above half tide to inches, and consider this a distance. In Norie Table 2 with this course and distance find the corresponding D. lat. Consider this as inches, which must be added or subtracted from the half spring rise according as the time from high water is less or more than three hours, the result being the correction to be applied to the sounding taken with the lead.

Stellar Navigation. The student will learn under Astronomy how to distinguish the principal stars [see page 6116], and he may find help from Rosser's "How to Find the Stars," which is almost a sailor's classic. We shall only deal with how to use the stars for navigation.

To find mean time at which a given star will be on meridian of the observer. Take Norie Table 44, or Raper Table 27. Look and see if time of meridian passage of star is more or less than 12 hours on the day given. If more than 12, count it as the previous day for looking in the Nautical Almanac: if less, count in the same day. From the Nautical Almanac take out star's right ascension, R.A., for the nearest day, also take out the sidereal time, from page II of the month, for the day you are working with. From the star's R.A. subtract the sidereal time, adding 24 to the R.A. if necessary. Result is mean time of star's meridian passage. From Norie Table 37 or Raper 24 take out the minute and seconds corresponding to the mean time nearly. Subtract them from the mean time nearly, and result is mean time the star will pass the meridian at Greenwich. Find longitude in time, and take from Norie or Raper, same tables, the minutes and seconds corresponding to longitude in time. Apply this correction to time star is on meridian of Greenwich; West longitude subtract, East longitude add. Result is mean time star is on the meridian of the observer. If result is less than 12 it is p.m., if more, reject 12 hours and call remainder a.m.

The apparent time a star will be on the meridian of the observer can be found by inspection in Norie Table 44 or Raper Table 27.

To find the R.A. of the meridian, apparent time being known, write down astronomical time at ship, underneath it place sun's R.A. from Nautical Almanac for Greenwich day, and the correction for the hours and minutes of Greenwich time calculated from the variation in 1 hour of the sun's R.A. From the sum reject 24, if sun is more than 24 hours, if not the answer is the R.A. of the meridian. A star is to the east of the meridian if its R.A. is more than the R.A. of the meridian; it is to the west if its R.A. is less than that of the meridian. A star passes the meridian to the north of an observer if its declination is to the northward of observer's latitude; it passes south if the star's dec. is southward of the observer.

Longitude by Chronometer and Star's Altitude. The altitude of a star is taken in the same way as the altitude of the sun. Find Greenwich mean time as in longitude by chronometer. Correct the star's observed altitude for index error, dip and refraction, as for sun, and thus get true altitude. From Nautical Almanac take star's R.A. and declination, and get the polar distance. Take also sidereal time for Greenwich date, correcting it for the hours and minutes of the Greenwich time by Norie Table 38. The correction is always to be added to the sidereal time, and the sum is mean sun's time. Now find the star's hour angle in exactly the same way as for the sun. If the star is to the east of the meridian subtract the hour angle from 24 and the remainder will be the westerly hour angle.

Find mean time at ship. Place star's westerly hour angle beneath the R.A. and add. Sum is R.A. of meridian, from which subtract mean sun's R.A., borrowing 12 hours if necessary. Remainder is mean time on ship. Now for longitude. Place Greenwich mean time underneath mean time on ship, and subtract the less from the greater. Convert remainder into degrees, etc., for longitude which will be east or west according as the Greenwich time is less or more than ship's time.

To Find True Azimuth of Stars. Find the mean time at ship, or apparent time, as may be most convenient. Then find hour angle of star, which, if more than 24, reject the 24, and if more than 12 but less than 24, subtract it from 24. In the time azimuth tables find the star's hour angle in the right-hand column of the page, under P.M. Name the azimuth according to the rules at the foot of the page in the tables.

Reduction to the Meridian. This is a very accurate method of finding the latitude by the altitude of a star or the sun. In this problem we have to find the difference between the meridian altitude and the true altitude of the observed object. First find the apparent time at Greenwich, and then the corrected declination. Then find the true altitude as we have aleady learnt how to do. Now to find the correction for the meridian altitude. Then take out the following logs from the tables.

Time from noon log from Table 31. Log cos latitude by account, log cos declination, log cosec of estimated zenith distance, which zenith distance you get by adding the latitude estimated and the declination if of different names, and subtracting them if of same name. Add the four logs together and cast out the tens from the index. The result is the log sine of half the reduction, which must be taken out from Norie Table 25 and multiplied by two. This reduction is always to be added to the true altitude, and will then give the meridian altitude.

Take the meridian altitude and subtract it from 90; the remainder is the meridian zenith distance, which is named of an opposite name to the bearing, S when bearing is N; N when bearing is S. Below the new Z. D. place the corrected declination. If of the same name add, if of different names subtract. The result is the latitude of the same name as the greater of the Z. D. and declination. This is the latitude at the time of taking the observation.

Sumner's Method for Finding Latitude and Longitude. This is rather a complex method of finding the position of a ship when in doubt, and no moon sight obtainable. Two altitudes of the sun's lower limb are taken, the time between them noted and also the run of the ship during that time. Two latitudes, between which the ship is fairly certain to be, are assumed: Chronometer times of both observations must also be taken. Here are the rules.

With the first Greenwich mean time find sun's declination and polar distance and equation of time. Correct first observed altitude and obtain true altitude. With this true altitude, the lesser assumed latitude, and the polar distance, find hour angle, as in longitude by chronometer, and from hour angle deduce a longitude, which call A. With same true altitude and greater assumed latitude proceed as before and find second longitude, which call B.

With the second observed altitude and Greenwich mean time do exactly the same, finding longitude E with lesser, and longitude F with greater assumed latitudes. Now take a chart and on parallel of lesser latitude lay off the first of the longitudes, namely A. Call the point 1. On the second assumed latitude lay off longitude B, and call point 2. Join 1 and 2, and that gives line of position for first altitude, the direction of which can be obtained from the compass on the chart. Take any point in the line of position and from it lay off the courses and distance the ship has made in the interval between the two observations. Through the end of this distance draw a line parallel to the line 1 2, and call this line KL. Lay off the other longitudes E and F on their assumed parallels of latitude, naming the points 3 and 4. Join 3 and 4, which gives us the line of position for the second altitude. Where the line 3 4 crosses the line KL is the ship's position when the second altitude was taken. To find the sun's bearing at the time of taking the first altitude, draw a line from the ship's position at right angles to the line of position, to the eastward if the first observation was taken a.m., but to the westward if taken p.m.

Latitude by Altitude of Polar Star. The Polar Star is not situated at the North Pole, but about $1\frac{1}{4}°$ from it, so certain corrections have to be made to the observed altitude according to latitude, time, etc. These corrections are known as first, second, and third, and can be found in the Nautical Almanac. First find Greenwich time, and thence sidereal time of observation of star's altitude. Correct observed altitude for index error, dip and refraction, and from this altitude deduct 1′, giving the reduced altitude. With sidereal time of observation take out first correction from Nautical Almanac, with it proper sign, and apply it to the reduced altitude. Result is approximate latitude. With true altitude and sidereal time take out second correction and add it to the approximate latitude. With the day of the month and sidereal time take out third correction, which is also added to the result from the last addition to the approximate latitude. The result is required latitude of ship which is always North.

Latitude by Meridian Altitude of Moon. Find moon's meridian passage. On page 4 of month of Nautical Almanac, take out upper meridian passage for astronomical day, and, if longitude is west, for day following; but if longitude is east, for day previous. Subtract the less from the greater. The result is daily retardation. Apply this to longitude in time, getting proportion of daily retardation, or correction for retardation. This is added to meridian passage of astronomical day if longitude is west, but subtracted if longitude is east. Result is time moon is on the meridian of ship.

Moon's Declination. In the Nautical Almanac the moon's declination is given for every hour of the day, and the variation in ten minutes. Take out these quantities for the Greenwich day and hour, and multiply the variation for one minute by the minutes and tenths thereof in the Greenwich time beyond the hours. Divide by six if necessary. The result is the correction to be added if the declination is increasing, or subtracted if it is decreasing. The result is the corrected declination. The semi-diameter and horizontal parallax are found as follows: From Nautical Almanac take out both for the day, for noon if Greenwich time is less than 12, but for midnight if more. Find the difference for the day by subtracting one amount from the next and multiply by the hours and tenths of an hour the Greenwich time is past noon or past midnight; divide answer by 12. This gives the correction for semi-diameter or for horizontal parallax, the process of correcting both up to this point being identical. Look in Table D. of Norie's Tables, and find the augmentation for the semi diameter, and add it to the corrected semi-diameter. In Table E (Norie) find the reduction of the horizontal parallax, and subtract it from the corrected horizontal parallax.

Take the observed altitude, which is taken in the same manner as that of the sun, apply index error, subtract the dip, subtract the refraction, add the augmented semi-diameter if altitude of lower limb was taken, but subtract if upper limb was observed. Then add the parallax, and the result is the moon's true altitude.

To find the latitude, subtract the true altitude from 90, and name it the opposite way to the bearing of the moon. This is the zenith distance. Apply declination as in sun's altitude, and thence obtain the latitude.

Napier's Diagram. This is an ingenious diagram by means of which the deviation of a ship's compass can be found sufficiently accurately for practical purposes. The bearings of a distant object are taken with the ship's head at eight different equidistant points of the compass. The mean of the eight bearings is held to be the correct magnetic bearing of the object. To find the mean of the bearings we have three possible cases to consider. (1) If all the bearings are named alike. In this case add the bearings together, divide by eight, and name the result the same as the bearings. (2) If some bearings are named N. and some S. Take all the north bearings separately from 180 or all the south bearings from 180, whichever is easier. Add the bearings together, divide by eight, and name the bearing the same as those you have not altered. And (3) some bearings are east and some west. Add all east bearings together, and all the west. Subtract less from greater. Divide remainder by eight, and name result same as greater.

To Find Deviation. In the first two cases the difference between the correct magnetic bearing and each of the bearings of the standard compass is the deviation for each point of the ship's head. In the third case when the correct magnetic bearing and the bearing by the standard compass are both east or both west, subtract the less from the greater. If they are of different names, add them together. When the correct magnetic bearing is to the right hand of the standard bearing, the deviation is named east; if to the left, it is west.

Now take the diagram, and with dividers take from the centre line of Napier's diagram the number of degrees in the deviation for each of the eight points. Mark each on its proper line, and through the points thus obtained draw a flowing line, which will be the curve of the deviation. With this curve given a correct magnetic course you can find the compass course as follows: Place one leg of the dividers on the given course on the centre line and extend the other leg to the curve on or parallel to a plain line. Keep the leg on the curve, and move the dividers round till the other leg cuts the centre line in another place. The number of degrees from north or south there indicated is the compass course. To find correct magnetic course from a given compass course is only a reversal of the above proceeding. Given the direction of the ship's head, and the compass bearings of two distant points to find their correct magnetic bearings. Place one leg of the dividers on the direction of the ship's head on the centre line, and extend the other leg to the curve on or parallel to a dotted line. Lift dividers carefully, place one leg on the first given bearing on the centre line, and lay the other on the centre line, upwards if deviation for ship's head is west, and downwards if it is east. The number of degrees indicated will be the correct magnetic bearing from north or south towards east or west for that bearing. The other can then be dealt with in the same manner.

Instruments. We shall close this short set of lessons in navigation—all higher problems coming into the region of astronomy or mathematics—with a few brief remarks on the three principal instruments essential to safe navigation in their order of importance—namely, the compass, the sextant, the chronometer standard compass. Since upon the compass chiefly the safety of a vessel depends, it is most important that it should be of the best design and workmanship. Its position should be sufficiently distant from any particular masses of iron, especially those of a movable nature, and where an all-round view of the horizon can be obtained. The lubber line must be exactly in the fore-and-aft line, the pivot pin accurately centred, and the card evenly balanced in order to ensure satisfactory results.

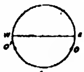
In the sextant an important point to be observed is that the vernier should fit perfectly flush on the face of the arc, and that the divisions are truly and cleanly cut. The instrument with 8-in radius is perhaps most serviceable, and neutral tinted glass is preferable for all screens. In fine clear weather take observations from the most elevated platform, and in foggy weather from the lowest point attainable. For stellar observations properly fitted binoculars are a boon. Carefully wipe glasses after using.

For long voyages three chronometers are deemed necessary. Select instruments by well-known makers, and have them rated for temperature. They should be secured in a specially constructed box, having padded sides and glass top, in a part of vessel free from vibration and as far removed from iron structural parts as possible. No compass or magnet should be near them. Wind punctually at same hour every day, and compare rates.

Continued

A SHORT DICTIONARY OF TERMS USED IN NAVIGATION

AMPLITUDE—The amplitude of an object is the arc of the horizon between the east and west points and the object when rising or setting. In 1, OE and OW are amplitudes of O rising and setting.



1.

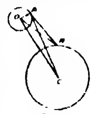
Apparent Altitude—The apparent angular height of the object's centre above the sensible horizon.

Apparent Time—The angle at the pole between the meridian passing through the sun and the meridian of the observer, reckoned westerly.

Arc of a Circle—A portion of its circumference.

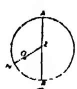
Astronomical Time—The time reckoned from noon to noon, and used in astronomical calculations.

Augmentation of Semi-diameter—The apparent increase in semi-diameter arising from decreased distance of observer from the object as it rises. Or, again, it is the difference in the semi-diameter brought about by the observer not being situated in the very centre of the earth. In 2, angle C is nautical semi-diameter; angle at R is augmented.



2.

Azimuth—Of a celestial body this is the arc of the horizon included between the north or south points and a vertical circle, drawn through the object. In 3, NZB is Azimuth of O for observer on AB.



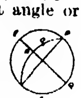
3.

CIVIL TIME—From midnight to midnight, the time in common use.

Compass Course—The angle a ship's fore-and-aft lines makes with the compass needle; otherwise, the track of the ship as shown by the compass.

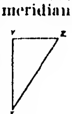
Complement of an Angle or Arc—The amount by which that angle or arc differs from 90°.

DECLINATION—The arc of a celestial meridian between the equinoctial and the object [4 OR].



4.

Departure—The distance in nautical miles which a ship has made good east or west of the meridian sailed from. In 5, XY is meridian sailed from, XZ is ship's course, and YZ is departure, XY a meridian, XZ ship's track.



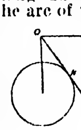
5.

Deviation of Compass—The angle the compass needle makes with the magnetic meridian, and caused by the iron in the ship.

Difference of Latitude (written *D. lat.*)—An arc of a meridian between two parallels of latitude.

Difference of Longitude (written *D. long*).—The difference of longitude between any two spots is the arc of the equator between the meridians of the two places.

Dip of the Horizon—The angle at the observer's eye between the visible and sensible horizons [HOS in 6].



6.

ECLIPTIC—The great circle in the heavens in which the sun appears to move among the stars. In 7, XY is the ecliptic.

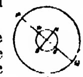
7.

Equation of Time—The difference between mean time and apparent time, and by its use the one can be converted into the other, and vice versâ.

Equator—A great circle supposed to be drawn round the earth 90° from each pole.

Equinoctial—The plane of the equator extended to the heavens and making a great circle therein. In 8, PQ is the equinoctial.

Error of Compass—The angle the compass needle makes with the true meridian.



8.

FIRST POINT OF ARIES—An imaginary spot in the heavens where the sun's apparent path crosses the equinoctial, from south to north.

GREATER CIRCLES—Those whose planes pass through the centre of a sphere [9].

9.

HOUR ANGLE—The angle hour of a star or other celestial body is the angle its meridian makes at the pole with the meridian of the observer. In 10, P is pole, PN meridian, O is body, NPA is hour angle.

10.

LATITUDE—The distance of any place north and south of the equator measured on a meridian.

Leeway—The angle a ship's track makes with her fore-and-aft line.

Longitude—The longitude of a spot is the arc of the equator between the first meridian of longitude and the meridian of the spot.

MAGNETIC COURSE—The angle a ship makes with the magnetic meridian.

Magnetic Meridian—The direction a perfect compass would point if in no way affected by local magnetic forces.

Magnetic Poles—The magnetic poles are situated, the North in lat. 70 N. and long. 97 W., and the South in lat. 73 S. and long. 147 E.

Mean Time—The time which would be shown by the sun if he revolved in the plane of the equator with the mean angular velocity with which he revolves in the ecliptic.

Meridian—A great circle passing through the poles and cutting the equator at right angles. In 11, NOS is a meridian.

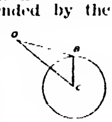
11.

NAUTICAL MILE—The length of a minute of arc of the meridian. It varies slightly with the latitude.

OBLIQUE ANGLE—One greater or less than a right angle; if greater, it is called obtuse, and if less, it is acute.

Observed Altitude—The angular height read from the observer's instrument.

PARALLAX—The angle at the centre of a celestial body subtended by the earth's radius at the position of the observer. In 12, the angle at O is parallax.



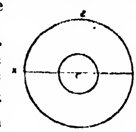
12.

Polar Distance—The arc of a celestial meridian between the object and the celestial pole. It is the complement of the declination [4, OP].

Prime Meridian or First Meridian—The meridian from which longitude is reckoned. For Englishmen, this is Greenwich.

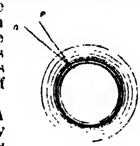
Prime Vertical—The vertical circle which passes through east and west points of the horizon.

RATIONAL HORIZON—A plane passing through the centre of the earth, every point of which is 90° from the observer's zenith. In 13, Z is zenith. XCY is rational horizon.



13.

Refraction—The bending of a ray of light towards the perpendicular when passing through the air. In 14, O is real place, P is apparent place of object.

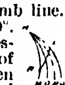


14.

Rhumb Line—A curve cutting every meridian it meets at the same angle. In 15, RL is a rhumb line.

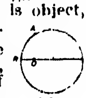
Right Angle—An angle of 90°.

Right Ascension—Of a celestial body this is the arc of the celestial equator between the First Point of Aries and the meridian passing through the object. In 16, ARO is object, A, First Point of Aries.



15.

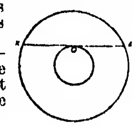
SEMI-DIAMETER—The angle at the observer's eye, subtended by the radius of a celestial object [R in 2].



16.

Sensible Horizon—A plane to which a plumb line at the observer's position is perpendicular, as XOZ [17].

Sidereal Time—Reckoned from the time the First Point of Aries passes the meridian.

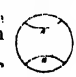


17.

Small Circles—Those which do not pass through the centre of a sphere. [18, A and B].

Spherical Angle—An angle formed by the intersection of two great circles [19].

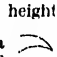
Supplement of Angle or Arc—The amount an angle differs from 180°.



18.

TRUE ALTITUDE—The true height above the rational horizon.

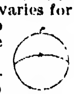
True Course—The angle a ship's course makes with the true meridian.



19.

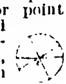
VARIATION OF COMPASS—The angle the magnetic meridian makes with the true meridian. It varies for different places, and is to be found marked on the charts.

Vertex of a Great Circle—That point on it nearest to the pole. In 20, X is the vertex, P the pole.



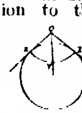
20.

Vertical Circles—Great circles passing through the zenith or point immediately overhead, and perpendicular to the horizon. In 21, Z is zenith, and all lines passing through it are vertical circles.



21.

Visible Horizon—The circle limiting the observer's view at sea. It increases in proportion to the observer's height above the water. In 22, O is the observer, XYZ the horizon.



22.

ZENITH DISTANCE—The zenith distance of a celestial object is the arc of a vertical circle between the object and the zenith of the observer.

ESPERANTO–GREEK

Esperanto by Harald Clegg;
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ESPERANTO

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By Harald Clegg

Suffixes

Of all the suffixes used to modify the meanings of Esperanto words there are none which are so often used, and which possess such remarkable power, as the pair *ig* and *iĝ*. They are chiefly employed in the construction of verbs, as is shown by the following examples.

IG. The suffix *ig* signifies to render, to cause to be done, to make. It has the power of making an adjectival root-word a transitive verb:

Forta, strong; *fortigi*, fortify (make strong). *Bona*, good; *plibonigi*, improve, make better.

From noun roots transitive verbs may be formed:

Nulo, nought (zero); *nuligi*, nullify. *Ŝtono*, stone; *ŝtonigi*, petrify.

An intransitive verb receiving this suffix becomes transitive:

Stari, stand; *starigi*, erect, make stand. *Kuŝi*, lie down; *kuŝigi*, lay down. *Boli*, boil; *boligi*, make boil.

If added to a transitive verb the result is another transitive verb:

Presi, print; *presigi*, cause to be printed. *Kompreni*, understand; *komprenigi*, cause to be understood.

IĜ. The suffix *iĝ*, on the other hand, signifies to become, to get. An adjectival root to which this suffix is applied becomes an intransitive verb:

Ruĝa, red; *ruĝiĝi*, become red, blush. *Grasa*, stout; *grasiĝi*, get stout.

IĜ added to a noun-root makes an intransitive verb:

Polvo, dust; *polviĝi*, become dust. *Amaso*, crowd; *amasiĝi*, become amassed.

An intransitive verb receiving *iĝ* becomes another verb of the same class:

Sidi, sit; *sidiĝi*, become seated. *Bruli*, burn; *bruliĝi*, become burning.

Added to transitive verbs, *iĝ* makes intransitive verbs:

Fermi, shut; *fermiĝi*, become shut. *Fini*, finish; *finiĝi*, become finished.

These two suffixes may also be used as separate verbs, when the result is nearly the same as when affixed.

Examples: *Igi lin feliĉa estas mia deziro*, To make him happy is my desire; *Poste la vetero iĝis pli bona*, Afterwards the weather improved.

The use of *ig* and *iĝ*, however, is by no means confined to the construction of verbs. Adverbs, nouns, adjectives and participles (active and passive) may all be produced by the use of the characteristic endings of these parts of speech. The passive participles *at*, *it*, *ot*, naturally cannot follow the suffix *iĝ*:

Examples: *Fortigante*, in making strong; *pliboniĝo*, improvement; *nuligita*, having been nullified; *ŝtoniga*, possessing power to petrify; *polviĝante*, in becoming dust; *amasigota*, about to be crowded together; *kredige*, in a make-believe manner; *edziĝo*, act of becoming a husband, wedding; *sidiĝinte*, after having become seated.

The numbers and some of the prepositions and fixed adverbs also give employment to *ig* and *iĝ*.

Examples: *Unuigi*, unite; *duobliĝi*, become doubled; *pliigi*, make more; *foriĝi*, become absent, leave; *eligi*, omit, leave out; *kuniĝante*, in coming together; *kvaronigi*, divide by four.

The remaining suffixes are: *ĉj*, *nj*, *moŝt*, *um*.

ĈJ denotes an affectionate diminutive of a masculine name, of which it follows the first two or three letters.

Examples: *Patro*, father; *paĉjo*, papa. *Vilhelmo*, William; *Vilĉjo*, Bill, Billy.

NJ has the same meaning in feminine names as above.

Examples: *Patrino*, mother; *panjo*, mamma. *Florenco*, Florence; *Flonjo*, Flo.

MOŜT denotes titles of all kinds.

Examples: *Reĝo*, king; *Lia reĝa moŝto*, His Majesty. *Princo*, prince. *Via princa moŝto*, Your Royal Highness. *Via moŝto*, Your worship.

UM has no definite meaning and is seldom used. The principal words formed by its aid are given below:

Kolo, neck; *kolumo*, collar. *Varma*, warm; *malvarmumo*, cold in head. *Plena*, full; *plenumi*, fulfil. *Oro*, gold; *orumi*, gild. *Arĝento*, silver; *arĝentumi*, plate with silver. *Aero*, air; *aerumi*, air a room, bed or clothes. *Ami*, love; *amindumi*, make love. *Dato*, date; *datumi*, date a letter. *Kruco*, cross; *krucumi*, crucify. *Vento*, wind; *ventumilo*, fan.

Compound Words

A large number of new words may be formed by suitably conjoining the root-words found in the Esperanto dictionary. The qualifying word or root-word is placed first, while the last word indicates the part of speech of the compounded word.

Examples: *Samideano*, a person imbued with the same idea (used in reference to their co-workers by Esperantists); *poŝtkarto*, postcard; *lernolibro*, instruction book; *dramaŭtoro*, dramatic author; *okulvitroj*, eye-glasses; *bonkora*, good-hearted; *laŭdezire*, according to desire; *vaporŝipo*, steamship.

Such words are not to be found in the foregoing vocabularies as their construction is left to the ingenuity of the student.

Abbreviations

Occasionally, for the sake of simplicity, and to avoid undue repetition of full words, the following abbreviations are used.

Sro., Mr.; *Sino.*, Mrs.; *Fino.*, Miss; *Dro.*, Doctor; *Prof.* Prof.; *Kio.*, Company; *Espo.*, Esperantisto; *k. t. p.* (*kaj tiel plu*), and so on; *k. c.* (*kaj ceteraj*), etcetera; *t. e.* (*tio estas*), that is; *ekz.* (*ekzemple*), for example; *Nro.*, number; *B. E. A. Brita Esperantista Asocio.*

The sign "&" should not be used; it is meaningless in Esperanto.

Vocabulary

anĝel', angel
ark', arch, bow
barel', keg, barrel
ber', berry
bind', bind (books)
deviz', device, motto
drog', drug
enu', be weary of
fabrik', manufacture
fand', cast, melt
flar', smell (v.a.) sniff
frot', rub
huf', hoof
incit', provoke, incite
jung', couple, harness
kaldron', kettle
kamen', fire-place
kanap', sofa
kandel', candle
kolon', column, pillar
kompar', compare
kork', cork
kravat', cravat, tie
led', leather
lim', limit, boundary
lu', rent, engage
majstr', master (science, art)
model', model
nask', bear, give birth
palp', touch, feel
plant', plant
procent', interest
prosper', prosper, turn out well
putr', putrid, rotten
raport', report, recount
rul', roll (v.a.)
sak', sack, bag
salajr', salary
scienc', science
seg', saw (v.a.)
sign', sign, token
sorb', absorb
sufer', bear, endure
ŝancel', shake, cause to waver
ŝraŭb', screw
ted', tedious, worrying
toler', tolerate
velk', fade
venk', conquer
vest', clothe

Exercise XX.

1. Dro. Zamenhof, la altestimata aŭtoro de Esperanto, naskiĝis la trian de Decembro, mil okcent kvindek naŭa. La hufbatoj de ĉevaloj aŭdiĝis. La fero fandiĝos. Ne ŝanceliĝu, sed tuj luigu tiun ĉambron al la fandejestro. En la aŭtuno la bruniĝantaj folioj falas de la arboj. Kvankam li estis forte vundita, kaj samtempe venkita, li ne mortis. La skribaĵo estas tie ĉi, sed oni devas sekigi ĝin per sorba papero. Ŝi toleris kaj suferis multon, sed ŝi ĉiam estis modelo de pacienco. Ĉu tio estas korktirilo, kio kuŝas sur la kanapo? Mi pensas, ke ne. La floroj, kiuj estas plantitaj en la plantejo, odoras dolĉe. Al malbonfarantoj, neniam prosperas. Mi estas devigata limigi miajn elspezojn, ĉar mi nun iĝis malriĉa. La raporto pri la kunsido estos sendata senpage.

2. Here is the sign by which I shall be recognised. In the public square is to be found a tall column, which the mayor erected to the honour of a well-known townsman. I will have the instruction books bound to-morrow. The water has become putrid, and is not drinkable. He hired an office at 15s. per week. Becoming angry, he put on his overcoat and disappeared. What do you mean? I was obliged to put a stop to his speech. At daybreak the sun rises and at the fall of eve it goes down. Did you inhale the odour of those growing flowers?

NOTE. Use the *ig* and *iĝ* suffixes where possible.

Geographical Names

Continents

Africa, *Afriko*
America, *Ameriko* (*Norda kaj suda*)
Asia, *Azio*
Australia, *Aŭstralio*
Europe, *Eŭropo*

Countries

Algeria, *Alĝerio*
Arabia, *Arabujo*
Austria, *Aŭstrujo*
Belgium, *Belgujo*
Bohemia, *Bohemujo*
Brazil, *Brazilujo*
Bulgaria, *Bulgarujo*
Canada, *Kanado*
China, *Ĥinujo*
Denmark, *Danujo*
Egypt, *Egiptujo*
England, *Anglujo*, *Anglolando*
France, *Francujo*, *Franclando*
Germany, *Germanujo*, *Germanlando*
Great Britain, *Granda Britujo*
Greece, *Grekujo*
Holland, *Holando*
Hungary, *Hungarujo*
Iceland, *Islando*
India, *Hindujo*
Ireland, *Irlando*
Italy, *Italujo*
Japan, *Japanujo*
Mexico, *Meksiko*
New Zealand, *Nova Zelando*
Norway, *Norvegujo*
Persia, *Persujo*
Poland, *Polujo*
Portugal, *Portugalujo*
Roumania, *Rumanujo*
Russia, *Rusujo*
Scotland, *Skotujo*, *Skotlando*
Spain *Hispanujo*
Sweden, *Svedujo*
Switzerland, *Svisujo*
Turkey, *Turkujo*
United States of America, *Unuiĝitaj Ŝtatoj Amerikaj*

Cities and Towns

Amsterdam, *Amsterdamo*
Antwerp, *Antverpeno*
Algiers, *Alĝero*
Athens, *Ateno*
Berlin, *Berlino*
Boulogne-sur-mer, *Bulonjo apud Maro*
Buda-Pesth, *Buda-Pesto*
Constantinople, *Konstantinoplo*
Dublin, *Dublino*
Edinburgh, *Edinburgo*
Geneva, *Ĝenevo*
Lisbon, *Lisabono*
London, *Londono*
Madrid, *Madrido*
Milan, *Milano*
Moscow, *Moskvo*
Naples, *Neapolo*
New York, *Nova Jorko*
Odessa, *Odeso*
Paris, *Parizo*
Prague, *Prago*
Rome, *Romo*
Rotterdam, *Roterdamo*
Saint Petersburg, *Sankta Peterburgo*
Vienna, *Vieno*
Warsaw, *Varsovio*
Washington, *Vaŝingtono*

Time

Various methods are used to denote the time:

3 o'clock, *la tria* (*horo*); 3.15, *kvarono de la kvara* (*horo*); 3.35, *tridek kvin minutoj de la kvara*, or *dudek kvin minutoj antaŭ la kvara*; 3.30, *duono de la kvara* (*horo*). But the simplest way is, perhaps, to use railway method, thus: 3 o'clock, *la tria* (*horo*); 3.15, *la tria* (*kaj*) *kvindek* (*minutoj*); 3.45, *la tria* (*kaj*) *kvardek kvin* (*minutoj*).

English Prepositions

The following sentences and phrases are for translation:

At (*laŭ*) your desire I wrote the letter. One of (*el*) us must be wrong. I am a faithful servant of (*al*) the King. A book of (*pri*) proverbs. The best way of seeing (*por vidi*) the town. He is a professor of (*ĉe*) the school. My love for (*al*) children. On (*ĉe*) my arrival. The smallest room of (*en*) the house. City (of) London. Month (of) May (*prepositions omitted*). Mr. N. of (*el*) the city (of) York (*Urbo Jorko*). Ring of (*el*) gold. The love of (*al*) God. God's love (*Amo de Dio*). He is a man of (*kun*) taste. A friend of mine (*Unu mia amiko*). A labour of love. Regiment of (*da*) soldiers. He fought with (*kontraŭ*) the thief. Mute with (*pro* or *de*) wonder. It is sold at (*po*) threepence the (for each) pound. I put it at (*por*) his disposal. At (*en*) London. This bill is payable at (*post*) 30 days. Somebody shot at (*sur*) me. They cried for (*pro* or *de*) joy. For (*dum*) a moment he was silent. He stayed at Paris for (*dum*) a week. I cannot carry it for (*tra*) such a great distance. She cried for (*pro*) fear that she would not see him again. He upbraided me for having gone away (*pro tio, ke mi foriris*). Catalogue will be sent on (*laŭ*) request. Southend on (*apud*) Sea. We shall arrive by evening (*vespere*) in (*en*) London. He ran three miles in (*dum*) the hour.

Key to Exercise XIX.

Li, neatendite, alvenis en Londonon lastan nokton. Ĉe la

mezo de mia ĝardeno kreskas pirujoj, prunujoj kaj grosujetoj. Krom tiuj, vi trovas ĉiujn specojn de legomoj. La servistino ĵus metis la manĝilarojn sur la tablon, sed kie estas la supujo, la salujo, la piprujo kaj la sonorilo? Vekite, la tajloro malfermis la okulojn, kaj vidis la seruriston staranta apud li. Estante nature timema, li iom balbutas, kiam ajn oni riproĉas lin. Kurinte rapide al la stacidomo, li ĝuste trafis la vagonaron, kiam ĝi (ĵus) ekiris. La leteroj estas senditaj afrankite. Kia stranga ŝvelaĵo estas sur via vizaĝo! Tiu ĉi verko estas dediĉita al mia plej amata amiko. Jen estas la monujo kaj la juvelujo, kiujn mi trovis sur la ŝtuparo apud mia oficejo. Multajn dankojn! Tiu ĉi cigaringo tre similas mian. Transpasante la straton, la infano subite falis sub la radojn de kaleŝo. Ŝarĝite de la ŝarĝistoj, la ŝipo eliris el la haveno. La tajloro garantiis, ke ĉi-tiu surtuto estas farita el la plej bona drapo. Remante, mi rompis unu el la remiloj. La fabelo, pri kiu li estis traktanta, ne estas entute vera. Turnante la okulojn al la vasta maro, mi vidis la ŝipon malrapide formovantan, ĝis kiam ĝi malaperis. Feliĉe la terura mulitado inter Rusujo kaj Japanujo nun ĉesis, sed ni ĉiam pripensos tiujn mortintaĵn militistojn, kiuj vane oferis siajn vivojn pro siaj landoj.

KEY TO EXERCISE XX.

1. Dr. Zamenhof, the highly esteemed author of Esperanto, was born on the 3rd December, one thousand eight hundred and fifty-nine. The hoof-beats of horses were heard. The iron will become melted. Do not hesitate, but at once let that room to the foundry master. In the autumn the brown-becoming leaves fall from the trees. Though he was badly wounded, and at the same time became defeated, he did not die. The writing is here, but it must be dried with blotting-paper. She tolerated and suffered much, but she always was a model of patience. Is it a cork-screw that lies on the sofa? I think not. The flowers, which were planted in the plantation, smell sweet. Evildoers never succeed. I am obliged to limit my expenses, as I have now become poor. The report of the meeting will be sent free of payment.

2. Jen estas la signo, per kiu mi rekoniĝos. En la placo, troviĝas alta kolono, kiun la urbestro starigis je la honoro de tre konata urbano. Mi bindigos la lernolibrojn morgaŭ. La akvo putriĝis, kaj ne estas trinkinda. Li luis oficejon po 15 ŝilingoj por ĉiu semajno. Koleriĝinte, li surmetis sian surtuton kaj malaperis. Kion vi volas diri? Mi estis devigata ĉesigi lian paroladon. Je tagiĝo la suno leviĝas, kaj je vesperiĝo ĝi subeniras. Ĉu vi flaris la odoron de tiuj kreskantaj floroj?

NOTE. The student is advised to get English-Esperanto and Esperanto-English Dictionaries. (British Esperanto Association, 13, Arundel St., W. C.: 1/8 each.)

ESPERANTO *concluded*

GREEK

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SECTION II. SYNTAX

The Dative Case

As we have seen, the Greek dative stands for three distinct cases: 1. Locative, 2. Instrumental, 3. The Dative Proper. We will now deal with these more fully.

1. The Locative. The locative survives in a few forms as a distinct case, the ending being ι short; but, generally, the locative coincides in form with the dative. It denotes (*a*) place where, (*b*) time at which.

PLACE WHERE. With names of towns—as: *Πλαταιᾶσι*, at Plataea (locative form); or *Πλαταιαῖς* (dative form). With names of countries—as: *Ἑλλάδι*, in Greece. It often denotes the sphere of action, whether in a locative form (as *οἴκοι*, at home) or in a dative form (as *δόμῳ*, in the house; *οὐρανῷ*, in heaven). From the locative, denoting "place where," is derived the use of the locative to denote direction, or the place of arrival, after a verb of motion—as: *χαμαὶ πεσεῖν* (from *πίπτω*), to fall to the ground; *γῇ ἔκειτο*, He lay on the earth; *ἐδέξατο χειρὶ κύπελλον*, He took a cup in his hand.

TIME AT WHICH. This is found in Greek only in dative forms; there are no locative forms for time—*e.g.*, *τρίτῳ ἤματι*, on the third day; *γήρᾳ*, in old age; *νουμηνίᾳ*, at the new moon, on the first of the month; *ὑστέρῳ χρόνῳ*, in after time.

2. The Instrumental. This case primarily denotes "association with," and hence "attendant circumstances" and "relation." The name "instrumental" is misleading, as the idea of instrument is subordinate.

(*a*) THE ASSOCIATIVE INSTRUMENTAL denotes association with a person, common after *ἕπομαι*, follow; *μίγνυμι*, mix; *ὁμιλέω*, consort with; *μάχομαι*, fight; *διαλέγομαι*, converse; *κοινός*, common; *ἴσος*, equal; *ὅμοιος*, like; *ὁ αὐτός*, the same—as: *οὗτός ἐστιν ὁ αὐτὸς ἐκείνῳ*, This man is the same as that.

(*b*) OF CIRCUMSTANCES ATTENDING THE ACTION—as: *ἦλθον πλήθει οὐκ ὀλίγῳ*, They came with no small crowd; *ἔπλεον δεξίῳ κέρᾳ ἡγουμένῳ*, They sailed with the right wing leading; *μίαν ναῦν αὐτοῖς ἀνδράσιν εἷλον*, They took one ship men and all (lit. with the men themselves). This has three special uses: 1. To denote the agent of a person—as: *θεοῖς σεσωσμένος*, saved by the gods (lit. with the help of the gods); *ὠφελητέα σοι ἡ πόλις ἐστιν*, The city must be benefited by you (verbal adjective); *παρεσκεύαστο τοῖς Κορινθίοις*, Preparations had been made by the Corinthians (usually after a verb in the perfect, or the verbal adjective; this is generally rendered by *ὑπό* and the genitive). 2. To denote the means or instrument—as: *ὁρῶμεν τοῖς ὀφθαλμοῖς*, We see with the eyes; and after *χρῆσθαι*, to use (which always takes the dative), meaning literally to serve oneself with—as: *χρῆσθαι ἱματίῳ*, to use (*or* wear) a garment. 3. To denote reason, cause, or ground—as: *τοῖς πεπραγμένοις φοβούμενος*, fearing on account of what had been done; *οὔτε πενίᾳ οὔτε ἀσθενείᾳ τετίμηται οὐδείς*, No one is honoured on account of poverty or weakness; *ἀποθνήσκει νόσῳ*, He dies of disease.

(*c*) OF RELATION, defining the action of a verb or the application of a noun. Of this there

are two special uses to denote Manner and Space. 1. *Manner*: as, σιγῇ, in silence, silently; βίᾳ, forcibly; τῷ ὄντι, in reality; ταύτῃ, thus; μανίαις ψαύων, tempting (the god) in his madness. Under this head may be classed the "Instrumental of Measure," denoting difference of extent—as: πολλῷ μεῖζον, much greater (lit. greater by much); τῇ κεφαλῇ ἐλάσσων, a head shorter; τοσούτῳ ἄμεινον, so much the better. 2. *Space:* either of space over which motion takes place, or of time through which anything lasts—as: τῷ χρόνῳ, in course of time; ἀγήρῳ χρόνῳ δυνάστης, ruler through endless (lit. ageless) time.

NOTE on the Instrumental Case: Homer has many archaic forms in -φι or φιν, which are properly instrumental—as: βίηφι, by force, but are also used as locatives—*e.g.*: ὄρεσφι, on the mountains. More loosely still, they are used as genitives or datives, as κατὰ Ἰλιόφι τείχεα, for Ἰλίου.

3. The Dative Proper. This is used in Greek only of a person, the person affected by the action, although in Latin it is used of a thing as well. It may either depend on a verb or not. 1. *Depending on a verb:* The verb may be either transitive—as: δίδωμι, give—*e.g.*, δός μοι τοῦτο, Give me this; or intransitive—as: ἀρέσκω, please; εἴκω, yield; πιστεύω, trust; πείθομαι, obey; ὀνειδίζω, reproach; βοηθῶ, help; πρέπει, it is becoming; δοκεῖ, it seems, etc., all of which are followed by the dative—*e.g.*, πιστεύω τοῖς φίλοις, I trust my friends; πρέπει μοι λέγειν, It befits me to speak. This dative is especially used of the possessor after the verb *to be* and similar verbs—as: τρεῖς δέ μοί εἰσι θύγατερες, I have three daughters. 2. *Not depending on a verb:* (*a*) Dative of Interest—as: πᾶς ἀνὴρ αὑτῷ πονεῖ, Every man labours for himself; ἐμῇ κεφαλῇ περιδείδια, I fear for my head. (*b*) Dative of Respect—as: θεοῖς τέθνηκεν, His death is the gods' concern. This dative is sometimes indistinguishable from the possessive genitive, except by some slight idea of the person being *concerned* in the situation—as: ἦρχον τοῦ ναυτικοῦ τοῖς Συρακοσίοις, They commanded (governs genitive) the navy of the Syracusans. (*c*) Participial Dative, either limiting the action—as: ἐν δεξιᾷ ἐσπλέοντι, On the right as one sails in (lit. With respect to one sailing in); συνελόντι, or, ὡς συνελόντι εἰπεῖν (participle of συνάιρεω), to speak concisely (lit. for one making it concise); ὡς ἐμοί, in my opinion; μακρὰν γὰρ ὡς γέροντι προυστάλης ὁδόν, Thou didst undertake a long journey for an old man; or predicatively after a verb like *to be*—as: αὐτῷ βουλομένῳ ἐστίν, He wishes it (lit. It is to him wishing it). (*d*) Ethic Dative, of the person sympathising or affected (personal pronouns only)—as: πῶς ἡμῖν ἔχεις; How are you (we wish to know)? ἀνάβαινέ μοι τὴν κλίμακα, Climb the ladder, I pray; τίς τέθνηκέ σοι; Who of your friends is dead?

NOTES. There is a peculiar use of the dative found in statements of time—*e.g.*, ἡμέραι ἦσαν τῇ Μυτιλήνῃ ἑαλωκυίᾳ (perfect participle of ἁλίσκομαι) ἑπτά, There were seven days since Mytilene had been captured. The dative follows many verbs compounded with prepositions—as: ὑπόκειται τὸ πεδίον τῷ ἱερῷ, The plain lies below the temple.

Attraction of the Relative

The relative pronoun in Greek is especially marked by attraction of case—*i.e.*, it either attracts its antecedent to its own case (Inverse Attraction), or is itself attracted to the case of its antecedent (Attic Attraction, as being in Attic the normal construction). The latter is by far the more frequent.

INVERSE ATTRACTION—as, οἴχεται φεύγων ὃν ἦγες μάρτυρα, The witness whom you brought has gone fleeing away (for ὁ μάρτυς ὃν ἦγες). This is especially frequent when the principal sentence is completed subsequently—as: θῆκαι ὅσαι ἦσαν τῶν τεθνεώτων πάσας ἀνεῖλον, They removed (ἀναιρέω) all the sepulchres of those who had died (θῆκαι for θήκας). Another instance of this attraction, common in prose, is the phrase οὐδεὶς ὅστις οὐ, There is no one who not—*i.e.*, everybody (ἐστί being understood). In the nominative there is no attraction, but in the oblique cases, whenever ὅστις is governed by a verb or some other word, οὐδείς is attracted into the case of ὅστις—as: οὐδένα κίνδυνον ὅντινα οὐχ ὑπέμειναν, There was no danger that they did not endure (for οὐδεὶς κίνδυνος ἦν ὅντινα, κ.τ.λ.); οὐδενὸς ὅτου οὐκ ἂν πατὴρ εἴην, There is no one whose father I might not be (for οὐδείς ἐστι, κ.τ.λ.).

ATTIC ATTRACTION. This usually occurs only when the relative would naturally have been accusative—as: ἀπὸ τῶν πόλεων ὧν ἔπεισε, From the cities which he persuaded (ὧν being for ἅς); τοῖς ἀγαθοῖς οἷς ἔχομεν, With the good things which we have (οἷς for ἅ). Especially when the antecedent is omitted—as: ἥμισυ οὗ διενοεῖτο, Half of what he intended (οὗ for ἐκείνου ὅ, Of that thing which); σὺν οἷς ἔχω τὰ ἄκρα καταλήψομαι, I will seize the heights with the men whom I have (οἷς for τοῖς ἀνδράσι οὕς); πρὸς οἷς ἐκτήσαντο, In addition to what they gained (οἷς for τούτοις ἅ). More rarely, and always with antecedent omitted, a relative is attracted from genitive to accusative, or from dative to genitive—as: ἀφ' ἧς ὠμόσατε ἡμέρας, From the day on which you swore (for ἀπὸ τῆς ἡμέρας ᾗ ὠμόσατε); and hardly ever from nominative to genitive—as: ὧν ἂν δόξῃ πέρι (for περὶ ἐκείνων ἃ ἂν δόξῃ), Concerning those things which may seem good to us. [Note the difference in accent when a preposition *follows* its noun: πέρι and περί.]

A similar construction is found with relative adverbs—as: διεκομίζοντο ὅθεν ὑπεξέθεντο παῖδας καὶ γυναῖκας, They brought over their wives and children from the places in which they had deposited them for safety (ὅθεν, from which, standing for ἐκεῖθεν ὅπου, from there where, *or* from the places in which).

NOTE. A peculiar attraction takes place in certain phrases with οἷος, such as: πιστεύω οἵῳ σοὶ ἀνδρί, I trust such a man as you (for τοιούτῳ οἷος σύ); τοῖς οἵοις ἡμῖν χαλεπόν ἐστι, It is hard for people like us (for τοιούτοις οἷοι ἡμεῖς, for such as we are).

Negatives

There are two negatives in Greek, οὐ and μή. It is rather hard to understand thoroughly the difference between them; only by noticing their usage carefully whenever they occur will the

student become quite conversant with their use. The following remarks give the broad outlines.

οὐ is specific, μή is general; οὐ denies, μή forbids or deprecates. In other words, οὐ is used in negative *statements* (including interrogative sentences), μή in negative *conceptions* (including purpose, consequence, prohibition and condition). What is said of οὐ and μή applies also to their compounds, οὐδείς, μηδείς, οὐδέ (not even), μηδέ, οὔτε (nor), μήτε, οὔποτε (never), μήποτε, etc.

In principal clauses οὐ is used in assertions, μή in commands and wishes. In subordinate clauses οὐ is used in causal and temporal sentences, μή in final (*i.e.*, expressing purpose) and conditional sentences. In indirect or reported speech—*i.e.*, Oratio Obliqua—the regular negative is οὐ, though some exceptions occur. (The Oratio Obliqua will be dealt with subsequently.)

Examples: πυρὸς ἑκὼν οὐχ ἅπτομαι, I do not willingly touch fire; εἰ ἐκεῖσε ἀπῆλθον, οὐκ ἂν εὗρον αὐτήν, If I had gone there, I should not have found her; οὐ βούλεσθε ἐλθεῖν; Don't you wish to go? οἰόμενοι τὴν βουλὴν οὐ ψηφιεῖσθαι, Thinking that the senate would not vote; ἐπειδὴ οὐχ εἷλον, ἀπεχώρησαν, As they could not take it, they went away. ἀπῆλθον ἵνα μὴ ἴδοιμι αὐτόν, I went away in order that I might not see him; μὴ τοῦτο δράσῃς, Do not do this; μηκέτι ζῴην ἐγώ, O that I may live no longer! εἰ μὴ τοῦτο δρῴην, μαινοίμην ἄν, If I were not to do this, I should be mad; ᾔτησα μὴ δρᾶν, I asked him not to do it.

When used with single words, οὐ is definite, μή indefinite. Thus: οἱ οὐκ ἀγαθοὶ πολῖται, Certain definite citizens who are not good; οἱ μὴ ἀγαθοὶ πολῖται, Any citizens who are not good; οἱ οὐ νοσοῦντες, Certain special not diseased persons; οἱ μὴ νοσοῦντες, Those who are not ill, the class of not diseased persons; τὸ μὴ καλό, Whatever is dishonourable; τὸ μὴ δύνασθαι, inability; τὸ μὴ ὄν, non-existence; οὔ φημι, I say not, I deny. In direct questions οὐ expects the answer *Yes* (Latin *nonne*), μή expects *No* (Latin *num*). Sometimes the fuller form ἆρα οὐ or ἆρα μή is found. Thus, ἆρα μή (or simply μή) βούλεσθε ἐλθεῖν; You don't wish to go, do you?

There seems very little difference between the use of οὐδέν and μηδέν as nouns (= nothing), but after the article the forms beginning with μή are alone used—as: οὐ γὰρ ἠξίου τοὺς μηδένας, For he used not to value men that were nobodies.

In Greek, as a rule, two negatives do not nullify each other and make a positive; they rather strengthen the negation. Thus, "I never heard anything anywhere from anybody" would be οὔποτε ἤκουσα οὐδὲν οὐδαμοῦ οὐδενός, "I never heard nothing nowhere from nobody." μὴ δίδου μηδὲν μηδενί, Do not give anything to anybody. So with οὐδέ, not even—as: οὐδεμία γυνὴ οὐδὲ πειρᾶται, No woman even tries.

After a word of negative meaning, Greek often has a negative expression where other languages would have an affirmative. 1. After a comparative—as: πόλιν ὅλην διαφθεῖραι μᾶλλον ἢ οὐ τοὺς αἰτίους, to destroy the whole city rather than the guilty; the idea being that in all comparisons the very notion of preference also implies rejection or denial. 2. After a verb of negative meaning (*e.g.*, deny, dispute, hinder, distrust), where μή with the infinitive is used for the infinitive alone—as: They hindered me from coming, ἐκώλυσάν με μὴ ἐλθεῖν; I deny that he did it, ἀπαρνοῦμαι μὴ ἐκεῖνον δρᾶσαι; and even after a noun—as: ἡ ἀπορία τοῦ μὴ ἡσυχάζειν, the impossibility of keeping quiet.

μὴ οὐ. When such a verb of negative meaning as we have just considered is itself negatived by οὐ, Greek requires the negative οὐ to be put in the subordinate clause as well, so that in the latter clause we get the combination μὴ οὐ—as: οὐκ ἐκώλυσάν με μὴ οὐκ ἐλθεῖν, They did not hinder me from coming; οὐκ ἀπαρνοῦμαι μὴ οὐκ ἐκεινὸν δρᾶσαι, I do not deny, etc.; τί μέλλει μὴ οὐ παρουσίαν ἔχειν; What hinders him from being present? (*i.e.*, nothing hinders).

οὐ μή. This is used (1) interrogatively with the future indicative to express a strong prohibition—as: οὐ μὴ ἐξεγερεῖ; Will you not not-rouse? —*i.e.*, do not rouse; οὐ μὴ φλυαρήσεις; Will you not stop talking nonsense?—*i.e.*, stop talking nonsense. (2) With the subjunctive, mostly with the aorist—as: οὐ μὴ ἔλθῃ, There is no chance of his coming; οὐ μὴ ληφθῶ, There is no chance of my being caught. This expression is probably the negative of μὴ ληφθῶ in its Platonic sense of "I shall probably be caught," which was a revival of the Homeric use of the construction as meaning "I fear I shall be caught." The original meaning of μὴ ληφθῶ was "May I not be caught!" whereas in Plato the same construction becomes a cautious assertion (μὴ φαῦλον ᾖ, It will probably prove bad); hence οὐ μὴ-ληφθῶ, There is no reason to suspect I shall be caught.

Oratio Obliqua (Indirect Discourse)

Students of Latin have the advantage of understanding this construction; they have the disadvantage, however, of bringing to the study of the Greek construction certain preconceived ideas which, though excellent from the point of view of Latin, are inconsistent with the Greek idiom. Everyone knows what direct speech is: "I am well," "Who are you?" "Do this!"—these are examples respectively of direct statement, direct question, and direct command. Now if we wish to quote someone as using these expressions, we may either quote them *directly*—as: He said, "I am well"; He asks, "Who are you?"; He commands, "Do this!"; or *indirectly*—as: "He said that he was well"; "He asks who you are"; "He orders you to do this." With this latter indirect use we are now concerned.

I. Indirect Statement. In Latin the natural way of expressing this is by means of the accusative with the infinitive; in Greek this is only *one* of the natural ways.

1. Accusative and Infinitive. This is used after verbs of *saying* and *thinking* to express the English "that . . . . ."—as: He said that the laws were unjust, ἔλεγε τοὺς νόμους εἶναι ἀδίκους; Thinkest thou that I am unhappy? νομίζεις δυστυχεῖν ἐμέ; Also after impersonal verbs—as: "it was agreed that," "it happened that," "it was proposed that," etc. The negative used here is οὐ, not μή.

In the following two points the accusative

and infinitive construction in Greek differs from Latin—

ACCUSATIVE WITH PARTICIPLE. After verbs of *feeling* and *knowing* (perception as opposed to statement proper) the accusative with the participle, and not with the infinitive, is the rule—as: οἶδα αὐτὸν λυπηρὸν ὄντα, I know that he is troublesome; τυράννους ἐκπεσόντας ᾐσθόμην, I perceived that the tyrants had been expelled; τὸν Μῆδον ἴσμεν ἐκ περάτων γῆς ἐλθόντα, We know that the Mede came from the ends of the earth; οἶδά σε ἀγαθὸν ὄντα, I know that you are good.

INFINITIVE ATTRACTION. If the subject of the Infinitive (or participle) is the same as the subject of the principal verb, it is put in the *nominative*, instead of in the accusative, by a kind of attraction—as: Ἀλέξανδρος ἔφασκεν εἶναι Διὸς υἱός, Alexander used to assert that he was the son of Zeus; πλούσιοι οἰόμεθα ἔσεσθαι, We think that we shall be rich; αἰσθανόμεθα γελοῖοι ὄντες, We perceive that we are ridiculous; οἶδα ἀγαθὸς ὤν, I know that I am good. Notice that in these examples the pronouns "that *he*," "that *we*," etc., are not expressed. There is no need to express them, unless there is an especial emphasis laid on the pronoun, as, for example, οὐκ ἔφη αὐτὸς ἀλλ' ἐκεῖνον στρατηγεῖν, He said "Not I, but you, are general" (lit., He said that not himself but that man was general; here we have the two constructions, nominative with infinitive, and accusative with infinitive); ἐκείνην μὲν καλὴν ἔφη εἶναι, αὐτὸς δὲ αἰσχρός, He said that she was beautiful, but that he himself was ugly. This construction makes Greek beautifully clear; it avoids all the clumsiness of the English reported speech, in which it is often difficult to make out the persons to whom the various pronouns refer—as: "He said that he would soon teach him better manners, and if he did not take care he would have to look to himself, for he was determined to put a stop to his impudence."

2. Instead of the accusative with the infinitive it is equally good Greek to translate the English "that" by ὅτι or ὡς followed by the verb in a *finite* mood. The negative here too is οὐ. Examples: λέγει ὅτι γράφει, He says that he is writing; εἶπεν ὅτι γράφοι, He said that he was writing; λέγουσι ὅτι ὁ βασιλεὺς σφᾶς ἔπεμψεν, They say that the king sent them; ἔλεξαν ὅτι ὁ βασιλεὺς σφᾶς πέμψειε, They said that the king had sent them.

From these examples it will be noticed that after a main verb in a Primary tense (*i.e.*, Present, Future, Perfect), the verb in the ὅτι clause remains in the same mood and tense as in the corresponding direct statement; but after a Historic main verb (*i.e.*, Aorist, Imperfect, Pluperfect) the verb in the ὅτι clause becomes *optative*. This is the strict rule, but frequently, for the sake of vividness, the rule is relaxed, and instead of the optative in the latter case, the indicative is found, the actual tense and mood used by the speaker being thus preserved in the reported speech. Examples: ἔλεγον ὅτι ἐλπίζουσι σὲ καὶ τὴν πόλιν ἕξειν μοι χάριν, They said that they hoped you and the state would be grateful to me (the original mood and tense "they hope" instead of optative by strict sequence); ἧκε δ' ἀγγέλλων τις ὡς Ἐλάτεια κατείληπται, Some one was come reporting that Elatea had been taken ("Elatea has been taken," perfect indicative passive of καταλαμβάνω, instead of optative); εἰπόντες ὅτι πρέσβεις πέμψουσιν, ἀπῆλθον, They went away, saying that they would send ambassadors ("they will send," instead of πέμψοιεν, as strictly required). Here are two examples showing the strictly regular use with optative: ἐπειρώμην αὐτῷ δεικνύναι ὅτι οἴοιτο μὲν εἶναι σοφός, εἴη δ' οὔ, I tried to show him that he thought he was wise, but was not so; ὑπειπὼν ὅτι αὐτὸς τἀκεῖ (τὰ ἐκεῖ) πράξοι, ᾤχετο, Hinting that he would himself manage things there, he departed.

3. After verbs expressing *emotion*—*e.g.*, θαυμάζω, wonder; μέμφομαι, blame; ἀγανακτῶ, be indignant; αἰσχύνομαι, be ashamed; the Greeks used εἰ (if) instead of ὡς or ὅτι—as: θαυμάζω εἰ μὴ ἀσμένοις ὑμῖν ἀφῖγμαι, I am astonished that my arrival should be unwelcome to you. The negative here is always μή.

So far we have been dealing only with the principal clause in Indirect statement. We must now see what happens in a dependent or subordinate clause. Here again the Latin student must beware; for whereas in Latin the verb in a dependent clause in oratio obliqua is subjunctive, in Greek the subjunctive is never due to oratio obliqua. In Greek the rule is much simpler: if the principal verb is primary the dependent clauses stand exactly as they would if the statement were direct; if the principal verb is historic, all dependent verbs in the indicative or subjunctive should strictly become optative, though for the sake of vividness they are frequently retained in the indicative or subjunctive unchanged. Examples: ποιήσειν φησὶν ὃ μήτ' αἰσχύνην μήτ' ἀδοξίαν αὐτῷ φέρει, He says he will do whatever brings neither shame nor discredit to him (φέρει is exactly what it would be in direct speech); ἀπεκρίνατο ὅτι μανθάνοιεν ἃ οὐκ ἐπίσταιντο, He replied that they were learning what they did not understand (where ἐπίστασθε, indicative, you do not understand, becomes optative, though it might have remained indicative); ἔφασαν τοὺς ἄνδρας ἀποκτενεῖν οὓς ἔχουσι ζῶντας, They said they would kill the men whom they had living (ἔχουσι, indicative, retained, rather than changed into ἔχοιεν; their actual words were ἀποκτενοῦμεν οὓς ἔχομεν).

NOTE 1. The word "saying" or "thinking" need not be actually expressed in Greek in order to throw what follows into the accusative and infinitive construction. It is enough if the idea of saying or thinking is suggested only—as: ἐθάρσυνέ τε καὶ οὐκ εἴα τῷ γεγενημένῳ ἐνδιδόναι· τὴν μὲν γὰρ γνώμην αὐτῶν οὐχ ἡσσῆσθαι (Thuc. VI., 72), He encouraged them and would not allow them to yield in face of what had happened; for (he said) it was not their spirit that was broken (the idea of "saying" is suggested by ἐθάρσυνε).

NOTE 2. The accusative and infinitive is often employed after the article τό, making the sentence into a kind of substantive—as: τὸ ἁμαρτάνειν ἀνθρώπους οὐδὲν (ἐστι) θαυμαστόν, The [fact] that mortals err is not surprising; διὰ τὸ ξένος

εἶναι οὐκ ἂν οἴει ἀδικηθῆναι; Do you think you would not be wronged on account of your being a stranger? (Note the nominative ξένος; see Infinitive Attraction above.)

II. Indirect Question. This is very simple, the usage following the rule of the indirect statement with ὅτι—the verb in the indirect question being indicative or optative according as the main verb is primary or historic. And here, as there, the indicative may remain after a historic main verb for vividness. Examples: ἔρομαι τί δράσει, I ask what he will do; ἠπόρουν τί ποτε λέγει, I was at a loss to know what he meant (λέγει should strictly be optative, but the words of the actual direct question are allowed to remain, τί λέγει, What does he say?). Similarly if the direct question is a deliberative subjunctive, the subjunctive can remain after a historic main verb, instead of becoming optative—as: ἐβουλεύοντο εἴτε κατακαύσωσιν εἴτε τι ἄλλο χρήσωνται, They were deliberating whether they should burn them or dispose of them in some other way.

III. Indirect Command or Petition. The same rules apply here. Examples: κελεύει σὲ δρᾶσαι τόδε, He orders you to do this (negative μή); ἐκέλευσεν ὅ τι δύναιντο λαβόντας μεταδιώκειν, He ordered them, taking what they could, to pursue (his actual words were "take what you can," ὅ τι ἂν δύνησθε, and the subjunctive δύνωνται might have been retained here for vividness instead of optative); προεῖπον αὐτοῖς μὴ ναυμαχεῖν Κορινθίοις, ἢν μὴ ἐπὶ Κέρκυραν πλέωσι, They instructed them not to fight the Corinthians at sea, unless these should be sailing against Corcyra (subjunctive πλέωσι here retained instead of optative πλέοιεν).

Middle Voice

The Middle Voice, though reflexive in meaning, is not simply reflexive. Arising out of the reflexive use, there are many extended applications. The action is directed *towards* the agent, and hence we get three main applications of the middle, to denote action (1) upon, (2) for, and (3) within oneself.

1. Action upon Oneself. The agent is the indirect object of the action—as: δέχομαι, I take to myself; ἕννυμαι, I put clothes on myself; φέρομαι, I carry off for myself, I win (φέρω, simply *I carry*); τιμωροῦμαι, I redress my own wrongs, I take vengeance on (τιμωρῶ, I redress another's wrongs). The strictly reflexive use of the middle is not common in Greek; it is found with a few verbs like λούομαι, I wash myself; τρέπομαι, I turn myself, etc. But, while τύπτω means *I strike*, τύπτομαι does not mean "I strike myself." In other words the object is almost always indirect, not direct.

2. Action for Oneself, the Causative use of the middle; getting something done for oneself—*e.g.*, δανείζω, I lend, δανείζομαι, I get money lent me, I borrow; μισθόω, I let, μισθοῦμαι, I get something let to me, I hire; γράφω, I write, γράφομαι, I get a man's name written down, I accuse; ποιεῖν, to do, ποιεῖσθαι, to get done; θύω, I sacrifice; θύομαι, I get a sacrifice offered; παρατίθεμαι δεῖπνον, I have dinner served me.

3. Action within Oneself. The action is centred in the agent, and the reflexive sense is often very faint. This is found (*a*) in verbs of motion—as: ἔρχομαι, go; πέτομαι, fly; οἴχομαι, depart; φαίνομαι, appear (as opposed to the active φαίνω, I show); (*b*) in verbs of feeling or thinking—as: αἰσθάνομαι, perceive; οἴομαι, think; ἐπίσταμαι, know. Of the same kind is the reciprocal middle, used only in the plural—as: διαλεγόμεθα, we converse with one another; ἀμειβόμεθα, we interchange; διακελεύονται, they cheer one another on.

Peculiar Uses of the Middle in Certain Verbs

Active	*Middle*
ἀποδίδωμι, I give back ..	I sell
λύω, I release	I ransom
σπένδω, I pour a libation	I make a truce
ποιῶ, I value	I estimate
τίθημι, I put	I consider
σκοπῶ, I look at	I reflect on
ἐπιτίθημι, I put on	I attack
κοιμάω, I lull	I sleep
παύω, I stop some one ..	I cease

In all these it is easy to see how the different shades of meaning arise, if we bear in mind the essential idea of the middle voice. But in many cases there seems for all practical purposes to be very little difference in the use of the middle and of the active—as: ἰδεῖν and ἰδέσθαι, to see.

SECTION III. TRANSLATION

Vocabulary

gnat, κώνωψ (ὁ)	face, πρόσωπα (τά)
I came, ἦλθον	round, περί, governs accusative
neither ... nor, οὔτε ... οὔτε	own, ἴδιος, α, ον
I fear, φοβοῦμαι	until, ἕως οὗ
I scratch, ξύω	I am angry, ἀγανακτέω
I bite, δάκνω	thus, οὕτως
husband, ἀνήρ (ὁ)	I conquer, νικάω
I like, wish, θέλω	snare, δεσμός (ὁ)
hairless, ἄτριχος (from θρίξ, τριχός, hair, and ἀ denoting negation, a very common prefix in Greek)	spider, ἀράχνη (ἡ)
	paltry, εὐτελής, ες
	animal, ζῷον (τό)
	strong, ἰσχυρός
	power, δύναμις (ἡ)

A gnat came to a lion and said: "I neither fear thee, nor art thou stronger than I. For what is thy power? (say, For what to thee is the power?) Dost thou scratch with thy (the) claws and bite with thy (the) teeth? This even (καί) a woman does, fighting (μαχομένη, participle) with her (the) husband (dative). But I am much stronger than thou, and if thou wishest, let us go (ἔλθωμεν, subjunctive mood) even to war." And the gnat bit the hairless face of the lion round the nostrils. The lion scratched himself with his own claws, until he was angry. Thus the gnat conquered the lion and went away (ἀπῆλθε). But he fell into the snare of a spider, and lamented (ἀπωδύρετο) that he (had) conquered a lion, the strongest wild-beast, but was destroyed (ἀπώλετο) by a paltry animal, the spider.

Continued

PROFITABLE VEGETABLES AND FRUITS

Successful Cultivation of the Principal Vegetables. Market Packages. Why English Fruit-growing is not Profitable. Fruit Trees and Bushes. Packing Fruit

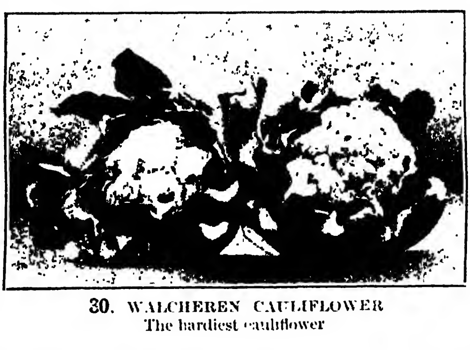
Continued from page 6534

By H. H. HAVART

A GOLDEN rule for success in profitable vegetable-growing, both in the private garden and for market purposes, is never to let the same crop grow on the same piece of ground two years in succession. When first the land or garden is taken in hand it should be divided into three sections: on one of these the root crops, such as carrots, parsnips, potatoes, etc., should be planted; on the second, the cabbages, peas, and beans; and on the third, the light salad crop, such as lettuces and radishes. In the second year the contents should be changed: the root crops should go where the salads have been; the salads to the cabbage patch; and the cabbages to where the root crops were the previous year. In the third season yet another change round should be made, each piece of land raising the crop it has not hitherto borne. These remarks do not, of course, apply to asparagus, while mushrooms, tomatoes, cucumbers, and seakale are generally most profitably grown under glass.

Artichoke and Asparagus. There are two kinds of artichoke, the globe and the Jerusalem. Of the former the leaves are eaten, and of the latter the roots. The globe artichoke is raised from seed sown in early spring, and planted out 2 ft. apart every way. Deep, rich loam is the best soil, and coal ashes and seaweed are valuable as manures. These artichoke beds must have a deep covering of litter during the winter months. The Jerusalem artichoke is misnamed, as it is a native of North America. This artichoke should be planted in early spring about 18 in. apart, and in any well-drained soil. It requires little or no attention after planting, though, if the soil is very poor, a little sulphate of ammonia may be applied.

Asparagus is a very profitable crop, but the reason that it is so expensive is because the capital and labour bestowed upon it must be locked up for at least four years before any return is shown. A rich, moist loam is necessary for the successful cultivation of asparagus, and it should be deeply dug, or even ploughed if a large area, several months before planting. In making a start it is best to procure one-year-old plants and put them in during the months of March or April, according to the season. Three years elapse before a main crop is ready to cut, though a few stalks may be obtained the second year. The asparagus bed should have a liberal dose of manure each autumn, and sprinklings of salt about once a month during the growing period. The roots should be in rows about 2 ft. apart, and 4 in. to 6 in. deep. If well looked after in the matter of autumn manuring, an asparagus bed will continue to yield a paying crop for upwards of twenty years.



30. WALCHEREN CAULIFLOWER
The hardiest cauliflower

Beans and Root Crops. The three chief varieties of beans are French, runner, and broad. The methods of growing are very similar: they may either be sown under glass in boxes in early spring and planted out, or sown in the open ground during March or April, followed by successive sowings at intervals of a fortnight to get continuous supply. Any loamy soil suits beans, but it should not be too crowded. Beans should be planted 6 in. apart, in rows, with 5 ft. between each row. Where grown in large quantities they are generally trained up sticks, but in small gardens they will thrive admirably against a wall or fence on horizontal strings or wires.

Root crops include the beetroot, carrot, leek, onion, parsnip, and turnip. The bulk of the seed of these vegetables is sown in spring, though later sowings are made for successional crops. The best soil is a loamy one that is not too rich, and the presence of sand in it is usually found to be beneficial. Fresh manure is not desirable, as, in the case of the carrot and parsnip, it has a tendency to produce forked roots. The manuring should be done immediately the previous crop has been lifted. The usual method of sowing is in rows about 9 in. apart, and the young plants are afterwards thinned to about a foot between each. The hoe should be used liberally between the rows during the growing season, to keep the surface soil stirred. Where grown on a large scale for market purposes about 5 lb. of seed of either variety is sufficient to sow properly an acre of land—to use more than this is to be wasteful. When the plants are about two months old a dressing of nitrate of soda should be applied, and the onion bed will benefit by a sprinkling of soot. It may be mentioned here, as a solitary exception to the rotation of crops that onions and leeks will thrive in the same ground year after year.

The Brassicas. Broccoli, Brussels sprouts, cabbage, cauliflower [30], and kohl rabi are all members of the great Brassica family, and though requiring to be sown at different times of the year are very similar in their requirements for successful cultivation. The soil must be well dug, and deeply, before they are planted, and the most economical plan is to sow the seed first in a small bed, or even in boxes, and plant the young plants out about 2 ft. apart every way. This is better than sowing the seed on the land itself in the first place, and thinning out afterwards, as by the latter method a large number of plants have to be wasted. Where cabbages, or

similar crops, are grown in large quantities for market it is, of course, necessary to devote a considerable area of land to their cultivation. These large plantations are usually broken up by means of the plough, and at the same time a generous dressing of horse manure is applied, as this encourages a full, rich growth.

Celery. To get celery at its best, seed should be sown as early in the year as possible in boxes, either in the hothouse or in a cold frame, according to the time at which it is desired to mature the crop. When planted out in the late spring, a deep, rich, heavily-manured soil is essential, and the plants should be placed in ditches or trenches at least 1 ft. in depth, the plants themselves being about 9 in. apart. These trenches must be gradually filled in with soil as the plants make growth, for it is only by this means that the stalks can be kept white and crisp. This process is known as "earthing up," and is carried out three or four times at intervals before the celery is fully grown. Plenty of water should be given every other day until the celery is earthed up for the last time, when all water should be withheld.

31. SEAKALE PACKED FOR MARKET

Salad Vegetables. Unless grown largely for market purposes it is doubtful if *cucumbers* are worth growing at all. Certainly they should be dispensed with where the space under glass is limited. Seed can be sown at any time during the first half of the year, according to the time at which the cucumbers are wanted. They must be planted in pots or pans of rich soil, and grown on in heat until the middle of May, when they should be planted out in a frame, or a heated bed, if an early crop is desired. The cucumber likes much moisture at the root, and a rich, loamy soil.

Lettuce may be had practically all the year round by growing in a gentle heat in the winter, and making successive sowings out of doors in the spring and summer. The seed should be sown about 1 in. deep in good, rich soil, and the seedlings thinned out to about 8 in. apart every way. When grown in large quantities for market, 1 lb. of seed is sufficient to sow an acre of land. When lettuces are being forced in frames, or heat, the temperature should never be allowed to fall below 65° F.

32. PEA GRADUS
The finest sort for market and private growing

Mushrooms. The best material of which to form a mushroom-bed consists of stable manure, half droppings and half litter, which should be first of all well turned over every day for about three weeks. The following method of culture, recommended by Messrs. Carter, is an excellent one: "The material should be put into a heap, the measurements of which should be, when made up, 2 ft. 6 in. at bottom, 2 ft. 6 in. high, and 6 in. wide at the top, and any length required, the whole to be firmly put together. After making the bed, put stakes down the centre, by which to gauge the heat, and cover all with long litter; after three or four days, pull out the stakes, and when the temperature is at about 80° the bed is ready for spawning. Break the bricks of spawn into pieces about the size of a hen's egg, and put into the bed about 8 in. apart. Cover the whole with fresh, fibrous loam, and beat it well, making the surface quite firm; lightly water, and smooth the surface with the back of a spade; finally cover up with long litter and Russian mats to keep away light, and excessive moisture. Mushrooms may also be grown in any shed or cellar where the temperature does not fall below 45°; the best site for a bed is a hard, dry floor. A moderate size bed would measure 5 ft. 6 in. by 4 ft. 6 in. by 1 ft. When made up and well pressed down, in about six weeks mushrooms should show, and the bed should then have a light watering with tepid water about every ten days, as success depends upon maintaining an even temperature."

Peas, Potatoes, Radish, and Rhubarb. Rich soil and plenty of water are the two chief requisites for successful pea-growing, and where systematic sowing is practised it is possible to gather this vegetable from May to November. A little lime in the ground is an advantage, and the peas should be put in, about 3 in. apart, in rows 2 ft. from each other, lettuces and radishes being sometimes planted in between. Peas may, with advantage, be forced under glass in a vinery after the grapes are cut, and before new growth commences. When sowing peas in May or June for late crops it is best to soak them in water for an hour or two before putting into the ground [32].

The ideal soil for *potato* culture is a well-drained, light, sandy loam. Wet soils must be avoided, as they have a tendency to spread potato disease. Potatoes planted by the middle of October in pots in a rich soil and a heated greenhouse will be fit for consumption at the end of the year, though they will not, of course, attain to any great size. They occasionally fetch very high prices in the market but cannot be looked upon as a paying crop, as the demand is very uncertain. Main crop potatoes may be planted early in April, about 12 in. apart, in rows 2 ft. away from each other. The use of the hoe is beneficial, and the potatoes should not be dug until the foliage has commenced to wither.

Radish is a crop which may be had all the year round by sowing in frames during the autumn and winter, and in the open air in spring and summer. Radishes do best in a rich soil, as the growth is quicker under such circumstances. Radishes in a poor soil are apt to be stringy, and hot and rank in flavour.

Rhubarb should be planted in the late autumn or early winter, in mild weather, in good, well-drained soil. The best way to increase it is by division of the roots, and an early crop may be obtained by covering portions of a plantation with boxes or barrels. Much, indeed, of the so-called forced rhubarb is raised in this way; but it may be had at almost any time during the year by forcing it in a temperature of about 70° F.

Seakale and Spinach. The best method of culture for *seakale* [31] is that recommended by the author of "Vegetables for Profit": "A good sandy loam is best suited for this crop. Richness is essential, and the area must be well drained, for, although a moisture-loving plant, no stagnant water must be allowed to accumulate. For this purpose the land must be deeply worked. An open situation is desirable in order to bring the crowns on in a vigorous manner; at the same time it should be as sunny as possible. After manuring, the area should be deeply ploughed in the early autumn, and the furrows left open throughout the winter. In the early spring harrow down and level. All weeds must be rigidly suppressed, and the ground made quite clean and friable before planting. If the soil be particularly light, roll after levelling, so as to make it firm. Mark out in rows 1½ ft. apart."

33. ESPALIER PEAR ON A WALL

Spinach is of very rapid growth, hence a sowing of it may be made at almost any time on ground that would otherwise lie idle for a few weeks, and a profitable crop obtained. Small patches of ground, however, should be employed in this way, as the demand for spinach is somewhat limited. A deep, moist soil is the best, and the seed should be soaked in water for a day before planting. Spinach should be sown in rows about 1 ft. apart, and very thinly.

Tomatoes and Herbs. To grow *tomatoes* to any extent, especially if for market, it is necessary to cultivate them under glass. In a few favoured spots against a sunny wall or fence they will ripen out of doors; but in our uncertain climate outdoor tomato culture, except as a hobby, is a risky and costly experiment. Seed should be sown in spring, and the boxes or pans containing it given a sunny position in the greenhouse. As soon as the seedlings are large enough to handle they should be planted out in the very small pots known as "thumb" pots, and subsequently into others of 5 in. in diameter. The tomato does not want a rich soil—old potting mould is quite good enough for it: neither is it wise to use animal manure. When the fruit is beginning to swell, a little chemical fertiliser may be used with advantage.

Mint, thyme, sage, parsley, lavender, rosemary, and tarragon are the *herbs* most generally in demand at the present day. For household use patches of them may be sown at any time during the spring in ordinary garden soil, where space can be found in the kitchen garden. Growing herbs, drying them, and doing them up in neat packets or bottles for sale, is a branch of gardening that may well be taken up by ladies, as it is a clean and not unprofitable occupation when once a connection is established. By making one sowing of herbs, say, in April, and another towards the end of June, a constant supply all the year round is ensured.

Packing for Market. As in the case of fruit, it is a great mistake to mix vegetables of different qualities together in one receptacle. It pays far better in the end to take the trouble of sorting the goods out into first and second qualities, and notify the salesman of this at the time of despatch. Much is gained, too, from a commercial point of view, by clearing the earth from root crops, as far as possible, before sending them away. A purchaser will always be inclined to give a higher price for vegetables so treated than he would for others upon which he would have to spend a lot of time in removing dried earth before he could expose them in his shop window. The majority of packages for the London and provincial markets are provided by the salesman who handles the goods. The nature of these packages necessarily varies a good deal according to what they are destined to hold. Local custom also determines their form to some

extent, but the following are those in most general use.

Bushel. A round basket 15 in. in diameter by 8 in. in depth, and holding ½ cwt. of potatoes or plums, or about 5 pecks of peas, or about 48 lb. of soft fruit.

Flat. An oblong, shallow basket, used for packing cucumbers, and holding from two to three dozen.

Half-bushel. A basket of the same shape as a bushel, but 12½ in. in diameter by 6 in. in depth.

Handle-basket. A basket chiefly used for packing grapes or tomatoes, and holding from 10 lb. to 12 lb. of the latter. It is somewhat oval in shape, and, as its name implies, has a handle over the centre.

Pad. An oval basket larger at the top than the bottom, and usually met with in one of two sizes, holding 1 cwt. or ½ cwt. of potatoes respectively. Cabbage and lettuce are often marketed in pads.

Punnets. These are the familiar baskets made of shavings, and are of the following regulation sizes: Mustard and cress: diameter, 5 in.; depth, 2 in. Mushroom: diameter, 7 in.; depth, 1 in., holding about 1 lb. Radish: diameter, 8 in.: depth, 1 in. Seakale: diameter at top, 8 in.; bottom, 7½ in.; depth 2 in.

Sieve. Another name for a bushel.

Many vegetables are sold by the bunch. A bunch of herbs is a handful; a bunch of carrots about 3 doz.; turnips, 2 doz.: leeks, 1 doz. Bundles of such things as rhubarb and asparagus vary according to the season. What is generally known as a bundle of radishes is technically called a "hand," and 6 "hands" go to a bunch in the wholesale trade. A roll of celery is either 8 or 12 heads, according to whether it is washed or unwashed. A score of lettuce or cabbage is 22, and a tally 60.

Fruit-growing. Profitable fruit-growing may be divided into two sections--growing for private use, and for the public market. In the former case the profit is arrived at by the saving which is effected in fruiterers' bills. A well-managed private garden of any dimensions should be able to produce all the fruit required for the household, except such tropical things as oranges and bananas, and though such a feat may tax the resources of the establishment where the tastes of the household run largely in the direction of nectarines and apricots, it should not be difficult of attainment where the hardier fruits are favoured.

Competition in the Fruit Market. It is frequently stated that fruit-growing for market cannot be carried on profitably in this country, owing to competition from the Channel Islands, France, the United States, and our own colonies. Under present conditions this may be true to some extent, but it is for the British fruit-grower to alter these conditions. The foreign fruit growers send good, up-to-date sorts, carefully picked and packed, to compete with home-grown fruit. The majority of our own growers are content to meet this competition with fruit from worn-out trees and bushes, which ought to have been grubbed up and burnt years ago, and such fruit is generally thrown higgledy-piggledy into dirty bushel baskets.

34. DWARF ESPALIER APPLE TREES

35. BLACK HAMBURGH GRAPES
Packed for market

Improving England's Wasted Orchards. The author of "The Wasted Orchards of England" admirably sums up the situation, as far as fruit-growing for profit is concerned, in his little book: "It is undoubtedly to the improvement of existing orchards that attention should first be directed, for even with a moderate change the value of the English orchards could be increased very largely. . . .

"Trees that have become so old and decrepit as to be past recovery should be swept away, for they serve no useful purpose, but simply become a harbour for insect pests of various kinds.

"All trees that possess a moderate degree of vigour might be greatly improved by having their heads moderately and judiciously thinned, and their roots dressed with either natural or artificial fertilisers, good farmyard manure being the best of the former, and super-phosphate of lime, muriate of potash, kainit, and nitrate of soda the best of the artificials. If the varieties are worthless, as in the majority of cases they are, and the trees are healthy, the orchards can be converted into a profitable state at a small outlay by grafting them with the finer cooking or dessert varieties suitable for the country. . .

"No apple or pear tree in a thrifty state should be cut down because the variety is indifferent, but should be grafted, as such trees, when grafted rather high up to admit of a score of such grafts being put in, form large and fruitful heads much more quickly than do newly-planted trees."

Many fruit trees are grown in different forms, according to their position, and the quantity of fruit desired. In a large market garden the apple, pear and plum are best grown in the large form of tree known as a standard, as this enables bush fruits, such as gooseberries and currants, to be grown underneath them, and thus effects an economy of space. Apples, etc., are themselves grown in bush form [36] in gardens of limited area where a good deal of fruit is required, while another form in which these trees may be trained is with their branches stretching out horizontally from the main stem (known as espaliers), radiating upwards in a fan shape, or

trained to a sort of combination of the two, called the pyramid. The fan and pyramid shaped trees are generally used against walls, with bird netting [33], while the espalier is most useful where the fruit and kitchen garden have to be combined, as the low-growing, horizontal habit of the trees renders them suitable for planting at the edges of beds filled with vegetables [34].

The Apple and Apricot. The apple may be planted in practically any soil that is not too heavy or clayey. A good rich loam is the best for most sorts, and a heavy soil may be improved by digging it out to a depth of 2½ ft., and putting in a layer of sand or road sweepings. The end of October or the beginning of November is the best time to plant, and the holes which are to receive the trees should be dug out a week or two before they are put in. After planting, the ground around the main stem of the tree should be covered with a layer of horse manure to prevent the winter frost reaching the roots. Pruning, which should be carried out the following autumn, should not be too severely done, only sufficient shoots being cut away to allow light and air to get to those which remain. Bush [36] and pyramid trees will require pruning every year, but the large standard trees not more than once in three years.

36. APPLE-TREE GROWN AS A BUSH
(Prince Albert)

The presence of lime in an otherwise loamy soil is an advantage when planting apricots. They need the shelter of a wall when grown in the open in our climate, and are best planted in late autumn, the same time as other fruit trees. A south, or south-eastern, aspect is best for them, and they do not require too much in the way of artificial stimulant. The flowers must be protected from late frosts in the spring—a layer of old fishing-net being usually sufficient for this purpose. When grown under glass the culture is the same as that of the peach.

Cherries and Figs. The most economical way of growing cherries is as standards, though, where space is available, a few of the choicest eating varieties may be given a position as fans or pyramids against a south wall. The soil most suitable for them is a deep, well-drained loam, with a dry subsoil, and pruning should not be overdone.

The fig is a much neglected fruit. A well-drained soil and a wall in a sunny situation are its chief requirements, but the soil must not be too rich, or otherwise leaves, and not fruit, will be produced. Figs need ample space, as they grow rapidly, and the fruit should be thinned as soon as it attains the size of a nut, otherwise a lot of hard, immature figs will be obtained instead of properly developed fruit. They may be grown in pots under glass in the ordinary way, starting them in February in a temperature of about 50° F.

Grapes and Melons. Profitable grape culture is impossible out of doors in this country. In favourable situations during exceptionally fine summers the fruit will often ripen, but it must not be looked upon as a profitable crop, and is best grown in the open air merely for its ornamental value. Under glass, vines may be planted in the late autumn, if dormant; or in the late spring if in a growing condition. A well-drained soil of loam mixed with lime, and a sprinkling of bone meal, is the best mixture to employ, shading the vines for the first few weeks from the full effects of the sun. A temperature of from 45° F. to 55° F. is sufficient at first, increasing gradually to 70° or even 80°, as the summer comes. Thinning grapes is a very necessary operation, and consists of snipping off small, badly-formed individual fruit when they are in an early stage of development, so as to allow those remaining on the bunch to swell properly. While the grapes are developing, give frequent doses of weak liquid manure. Grapes are sent to market in shallow baskets, each holding from six to ten bunches according to size [35].

To grow melons as a paying crop they should have a house to themselves. The seeds should be sown in pots at the beginning of the year, and kept in a temperature of at least 65° F. When they are about a month old they may be planted out in their permanent quarters, a hot bed, which consists of stable manure over which good rich loam has been spread and firmly pressed down. The temperature should then be gradually raised to 75° F. as the fruits develop, and they should be liberally supplied with water. To obtain properly-developed fruit, melons must be artificially fertilised by taking pollen from the male flower and placing it upon the stigma of the female. Melons fruit from five to six months after planting, and a succession may be obtained by later sowings.

The Peach and Other Trees. Where the peach can be grown out of doors, as it is possible to do in warm spots, its culture is the same as that of the apricot; usually speaking, however, it must be grown under glass. Peaches should be planted in September against the wall of the house, or trellis, at a distance of about 10 ft. to 12 ft. apart. A good, deep, rich, loamy soil is its favourite, but where this is not available ordinary garden soil with lime rubble added to it, and a few wood ashes, form an efficient substitute. The tree should commence at a minimum temperature of 45°, rising gradually to 85° as the fruit swells. At this period copious watering is necessary. To get the best fruit, the tree should be thinned freely—in fact, a space of 9 in. every way should be left between individual fruits.

The pear thrives under practically the same conditions as the apple, and is usually grafted on to the quince stock, though sometimes on to another

pear. Where the latter is the case a greater depth of soil is required for successful cultivation, as the roots of the pear reach further than those of the quince. Early pears should be gathered and eaten almost immediately; but late, or what are known as winter, pears should not be left on the tree after the middle of November. At about this period they should be picked, and stored in a cool room.

The plum, damson, and greengage are most accommodating fruit trees as regards soil. The plum flourishes, indeed, as far as fruit bearing is concerned, better in a light soil of moderate depth than in a deep, rich one. Plums are generally increased by budding or grafting, but greengages and damsons may be grown direct from the stone, planted late in the autumn. To get dessert plums to the highest pitch of perfection they should have the shelter of a wall, and, preferably, a southern aspect. When grown as standards they should be planted about 18 ft. apart every way. Care must be taken to keep the roots cool in hot weather by means of mulches.

The Strawberry and Bush Fruits. To have a supply of strawberries over the longest possible period it is best to have at least two plantations--one facing south or south-west for the early crops; and another in any sunny quarter for the later kind. Any ordinary loam will suit this fruit; but, as "The Strawberry Manual" says, "In the preparation of beds that are intended to be occupied for some years, thorough cultivation is desirable, and in the case of soil that is not in satisfactory condition it is essential. Bastard trenching is then the safest proceeding, turning the soil to the depth of two spits (20 in.), keeping the bottom spit down, and breaking the subsoil if it is at all hard or 'panned.' A heavy dressing of farmyard or stable manure (20 to 30 tons per acre) should be well incorporated in the soil as the work proceeds, and if a bed is carefully prepared in this way it will, with annual supplies of manure, give good results over as long a period as strawberries can be profitably kept upon the same land." The best time to plant is in the late summer or early autumn, when the danger of drought is practically over, and a distance of 2 ft. apart every way is the safest one for the plants. When the flowers are formed, a layer of straw should be placed upon the surface of the ground, upon which the fruit can rest and ripen, and also to protect it from being mud-splashed by heavy rains. All gathering of fruit should be done in the early morning.

For forced strawberries the soil in the pots should consist of loam with a little sand, and the addition of some bone meal. The pots must be well drained, and should be started in November in a temperature of 45°, advancing gradually to 70°. When the fruit begins to swell, nitrate of soda, or nitrate of potash, in the proportion of one ounce to two gallons of water, may be used as a stimulant.

The Bush Fruits. The currant, gooseberry and raspberry flourish under very similar conditions—the black currant preferring a spot which is more moist and shady than the others. To obtain the best results, bushes should not be planted too closely together, as, if this is done, it is impossible for them to develop properly and yield a good crop of fruit. About 5 ft. apart every way is a safe rule to remember, and from 2 ft. to 3 ft. for raspberries. Planting and pruning should be done in the autumn, and, for the reasons of light and air just mentioned, the latter operation should be performed so that the centre of the bush is left open. The orthodox garden loam, especially if a trifle sandy, suits all these fruits well. The profitable life of a fruit-bush is rarely more than six years, and at the end of this time it should be replaced with young ones.

Storing and Packing Fruit. For use during the winter and early spring months it is necessary to store quantities of apples and pears. The common practice of doing this, by relegating the fruit in heaps to the floor of an outhouse, and covering it with straw, is wrong and wasteful, and generally leads to the bulk of the supply becoming rotten and worthless. The proper way to store such fruit is upon tiers of wooden shelves in a building erected, or adapted, for the purpose, so that a current of air can circulate freely through all parts of it. The middle of November is quite late enough to gather fruit for store purposes, and all that is unsound should be rejected. It should also be gone over at intervals of, say, a fortnight, and any that show signs of decay picked out and thrown away, as otherwise there is danger of the whole stock becoming infected. For the same reason the apples and pears should not be allowed to touch each other if possible.

Apples and pears are usually packed for market in bushel baskets, or, in the case of apples, barrels which hold about three bushels each. The fruit should be carefully sorted into different qualites before packing, and the omission to do this is one of the reasons which has led the English grower to suffer so much at the hands of his foreign competitors.

The bulk of the bush fruits are also sent to market in bushel baskets, except in the case of a few of the choicest dessert varieties, which come in small strawberry baskets called "punnets." The punnets are packed in shallow trays each holding six or a dozen boxes, and these trays are again fitted into a larger box. The main crop of strawberries is marketed in "pecks," baskets holding about 12 lb. of fruit.

Packing Nectarines and Peaches. The utmost care must be used in handling and packing peaches and nectarines, as the slightest bruise, often indeed the mere pressure of a finger, is sufficient to set up decay. The orthodox market peach box is 2 ft. long, 14 in. wide, and 4 in. deep. The author of "The Book of the Peach," Mr. H. W. Ward, F.R.H.S., gives the following excellent directions on the subject of packing peaches: "The wood-wool should be placed inside the individual boxes to the thickness of 2 in. or 3 in. Then (the fruits having been previously wrapped in squares of tissue paper sufficiently large to admit of the ends being twisted together immediately over the crowns of the individual fruits) make an opening in the wood wool with the fingers at the end left-hand side of box sufficiently large to deposit a fruit therein, repeating the operation until the box is filled with fruit, being careful to leave a partition of wood-wool between each row of fruit every way in packing, in order to ensure the fruit reaching its destination in perfect condition. Put a sprinkling of the wood-wool over the fruit thus packed before fastening down the lid of the box. Shallower boxes may be used for packing nectarines in, as the fruits are smaller than peaches. In packing peaches for market, strips of tissue about three inches wide are used instead of square pieces. These, being doubled, are wrapped two or three times round the individual fruits half-way up, and then deposited that depth in the wood-wool in the manner indicated above. A double sheet of tissue is then placed over the packed fruit, followed by a layer of wood-wool of the proper thickness to admit of the lid shutting down closely on the box."

Continued

THE CAMERA & ITS WORK

Taking, Developing, and Printing Photographs. Enlarging. The Profitable Side of Photography

Group 5

PHOTOGRAPHY

Following PAPER-MAKING from page 6563

By J. M. GIBBON

WE should begin with a camera that is simple to manipulate and cheap to work. The older books recommend us to start with a stand camera. This may be all right if we start photography in winter, when most of our exposures have to be taken indoors or in dull weather. But summer is the best season to begin photography, and for summer the hand camera is the thing. We start, therefore, with a hand camera of the box form. We can use this as a stand camera quite easily, as even the cheapest makes have now an arrangement for time exposures as well as snapshots. Some of these cameras can be had as cheap as 5s. But if we reckon up the cost, we find that it is cheaper in the end to begin with a quarter-plate camera, giving pictures 4¼ in. by 3¼ in., and using glass plates, not celluloid or similar films. Plates of this size cost very little more than the smaller sizes, and are only half the price of films. The worst of a roll of films is that we have to wait till the whole set of six or twelve has been completed before we can develop, and in our impatience to complete the roll we are tempted to take snapshots that we do not really want. This is a most insidious way of running up the expense. Again, flat films are more expensive than glass plates.

The Modern Hand Camera. A number of excellent hand cameras of quarter-plate size, with twelve sheaths for plates, can be had for a guinea each. If we look about, we can get one of last year's make for still less. By the time these words appear in print it will be easy to get cameras of the 1906 make at a reduction, as dealers desire to clear their stocks for 1907. Secondhand cameras can be got still cheaper, but it is inadvisable to buy a guinea camera of a make earlier than 1905, as the fierce competition has made many improvements in small hand cameras during the last two years. The guinea hand camera has now, as a rule, diaphragms for "stopping down," an excellent shutter, focussing glasses (usually called magnifying glasses), and even a colour screen for landscape photography. The lenses also are greatly improved. One make (the No. 1 Clito) has even a rack and pinion focussing arrangement, the box form covering a bellows beneath. This is, perhaps, best of all, as it is better to focus with a single lens than by placing the so-called magnifying glasses in front. We must, however, get our dealer to guarantee our camera as light-tight, so that if we find any pin-holes or cracks which let in the light and spoil our negatives, we can get another camera in exchange. This the dealer will do in the hope of retaining our custom for photographic materials.

What will photography cost us, and what materials shall we require? Provided we have, to start with, a camera, a ruby lamp (from 1s. upwards), and three dishes (which may be had at 5d. each in xylonite), it should work out, allowing for failures, at about 1½d. per print.

The Nature of the Camera. But before we go on to the practice of photography we ought to understand the meaning of the terms in common use among photographers, some of which we have already used, and we ought to know how it is that the camera enables us to take photographs at all.

Take our guinea box-form camera and examine it. In the front end there is a hole in which a curved glass is inserted. This curved glass is the *lens*. At the back end is an arrangement for holding the plates. When the camera is closed, the only light that can reach the front of these plates must come through this lens, and the reason why the glass of the lens is curved is that this curvature concentrates the light on the photographic plate. The lens is covered up with a metal disc called the *shutter*. We press a knob and the "shutter" moves aside for a moment to let in the light and to make our "exposure."

Now the concentrated light coming through the lens forms an image on the photographic plate corresponding to the image which we receive through the eye. For the eye itself is only a kind of lens, and scientists have actually been able to take photographs through the eyes of animals placed in specially prepared cameras.

All the colours of Nature are reproduced in this image which comes through the lens. We can see this for ourselves in cameras which have a ground glass at the back end, or in the *view-finder* of our guinea camera, which shows a similar image to that thrown on the photographic plate.

How a Negative is Made. Now, to understand how a negative is made, we must understand how light and colour affect the photographic image. Here is a rough description which will serve our purpose. Light is reflected from objects in Nature as different colours, according to the particular rays absorbed and reflected [see page 3728]. Now the ordinary photographic plate is more rapidly affected by—is more "sensitive" to—some colours than others. Suppose we are photographing a landscape made up of a blue sky, a yellow house, and a girl with a red dress. The photographic plate is most sensitive to the blue. Then comes the yellow and, last of all, the red. Of course, the quantity of light conveyed by any of these colours may vary according to the strength with which these objects are lighted—for instance, by a sunbeam—and so modify this general truth.

Now the sensitive stuff (itself of a yellowish-white colour) fixed on the glass plate has been affected by being exposed to the colours, but so slightly that the affection is not visible to the eye. This is where the "development" comes in. The sensitive plate, after exposure, is taken into a dark-room and treated with certain chemicals. These chemicals darken the parts that have been affected, and clear away the rest. The result is that where the blue sky hit the sensitive plate we have the darkest marks; where the yellow house, we have medium darkness; and where the red dress, we have it much lighter. Where there was hardly any colour at all, as in deep shadows, we have the plate quite transparent. This, then, is the *negative*, in which the coloured image is reduced to a reversed and transparent image in black and white.

The Print. Now we have to make the *print.* A piece of specially-prepared paper is laid close against the negative, so that the light can reach it only through the negative. The light naturally passes most quickly through the most transparent parts of the negative and most slowly through the darkest parts. The result is that the paper is darkened most at the most transparent parts of the negative (where the shadows and the red dress were), then at the part corresponding to the yellow house, and, least of all, at the part corresponding to the blue sky, which remains almost white. In this way we get the print of our photograph. In tabular form we may express it thus:

Nature	*Negative*	*Print*
Blue	Dark	White
Yellow	Darkish	Darkish
Red	Light	Dark
Deep shadow	Transparent	Black

The Dark-room. Don't imagine that the "dark-room" is merely the drawing-room with the blinds drawn down. It is a room from which every chink of daylight or gaslight is excluded. Nearly every house has some little room or pantry or bath-room which can be used as a dark-room. Any room, of course, can be used as such at night. But a dark-room can be made for use by day by covering the windows with two coatings of the specially prepared red cloth sold by photographic dealers at from 10d. to 1s. per yard, and then by stopping up the chinks and the keyhole in the door.

Some plates are more susceptible to light than others. These are called *faster.* We should use fast plates from the very beginning. They cost no more, and they are so well made nowadays that they are just as easy to manipulate. There is less chance of under-exposure with a good fast plate, and the beginner is inclined to under-expose. If the light is too strong, we can easily *stop down.* Our guinea camera has probably three "stops" or holes in metal discs in front of the lens, which "stop out" superfluous light. The smallest hole—probably marked "*f* 22"—should be used on the brightest of bright summer days, but for an ordinary sunny day the middle sized hole—probably marked "*f* 11"—will do.

If fast plates are used, particular care must be taken that the dark-room in which the camera is loaded and the plates are developed is absolutely free from any light except that of the ruby lamp, or the red light that comes through the windows covered with the special cloth already described. The least trace of other light would probably ruin the plates. Good fast plates by most makers can be had at 1s. a dozen. These are usually wrapped inside the box in three parcels of four each, and in the packets of four are two pairs of negatives, arranged so that in each pair the sensitive sides of the negatives lie against each other. In this way we can tell in a dark-room, even without the aid of a lamp, which is the sensitive side of the negative. The sensitive side must, of course, face outwards and towards the lens in the sheath and in the camera.

The first snaps we should take in sunlight only. Leave the grey days for the man with a sixteen-guinea camera. Nine-tenths of the best photographs are made out of sunlight and sparkle, and the sunny photograph is the easiest to develop and to manipulate.

Cleanliness. Here are four rules that we should write and paste up on our door:

Keep your hands clean.
Keep your dishes clean.
Keep your lamp clean.
Keep your camera clean.

Suppose we have made one or two exposures, and wish to develop our negatives. What developer are we to use? There are dozens available, but we do not need to know of more than one or two. Hydroquinone is usually recommended for beginners, because it does not stain the fingers and the same dish will develop many negatives. Pyro-soda is, however, a far better developer, and if we rub our fingers with lanoline before developing, and wash our hands afterwards, they will not be stained. Another developer which combines the brightness of pyro-soda with the cleanliness and durability of hydroquinone is ortol; but country chemists do not always stock this. It is rather more expensive than pyro soda, but as it can be used both for gaslight papers as well as for negatives, it has its advantages.

It is far cheaper to make up our own solutions. If we look up the price-lists of the average London dealer, we will find that hydroquinone and pyro-soda are sold in solution in bottles at 1s. 3d. for 20 oz. If we buy these developers even in made-up powder form, and make up our own solutions, we can get 48 ozs. for 1s. If we buy the chemicals separately by the pound we can save still more. We can buy 16-oz. medicine bottles from our chemist for twopence each, and as these medicine bottles are marked out on the back into equal parts corresponding to "tablespoonfuls," we can measure the quantity of our solutions with ease and economy.

If we do not wish to go to the expense of buying scales, we can get our developer in tabloid form, accurately measured for us and made up. The Tabloid Brand pyro-soda gives us 40 oz. for 1s., and so too, with the hydroquinone. A point to remember in connection with our home-made solutions is that there must be no grains of powder floating about. The powder must be perfectly dissolved, otherwise we shall have spots on our negatives.

An Economical Developer. Here is a simple formula for a developer:

Pyro-soda.—No. 1: Sulphite of soda, 6 oz. (sold at 8d. per lb.); water, 32 oz.; pyrogallic acid, 1 oz. (sold at 10d. per oz.); citric acid, added after the solution of the sulphite of soda, in sufficient quantity to turn blue litmus paper red (sold at 2d. per oz.).

No. 2: Carbonate of soda, 3 oz. (sold at 5d per lb.); carbonate of potassium, 1 oz. (sold at 7d. per lb.); water, 32 oz.

Keep these solutions separate till just before development. An ounce of each combined in a dish with another two ounces of water will develop two or three quarter-plates in rapid succession. When the developer begins to get very brown, throw it out of the dish and mix some more. In hot weather more water may have to be added, otherwise the developer acts too quickly. In cold weather less water should be added. The No. 2 solution is the accelerator, and may be increased when the image is slow in appearing. Any number of variations on this formula—and, indeed, almost every formula for almost every developer—may be found in the "British Journal Photographic Almanac" (price 1s. 6d.), the most useful of all annuals. If we calculate, we find that by making up our own solutions we get 144 oz. of pyro-soda

for 1s. 4½d., instead of the 20 oz. for 1s. 3d. sold in bottles by the retail chemist. Of course, it is not necessary to make up such large quantities at once, but these proportions should be kept approximately.

The Process of Development. How, now, is the developing carried out, and what do we see? The plate is immersed, sensitive side upwards, in the developing solution, and the dish is gently rocked, care being taken that the whole surface is covered. We can tell which is the sensitive side of the glass, as it has a "matt" (dull) surface, whereas the glass side is glossy. Very soon we see dark spots appearing on the light surface, and then a reverse image of the picture we have taken builds itself up. This gradually darkens all over till the image is lost again in darkness. The negative is fully developed when we can see a suggestion of the image on turning the negative over carefully and looking at the glass side. Experience with a few negatives will soon show the depth to which it should be developed.

Fixing the Negative. When the negative has been sufficiently developed, it should be rinsed in a basin of clear water, and then "fixed" by immersion in a dish filled with a solution of "hypo," still in the dark-room. A pound of hypo (sodium thiosulphate) costs 2d., and when dissolved in 60 oz. of water—or proportionately—makes the fixing solution. The negative is left in the fixing solution till it is perfectly clear and transparent, all trace of white on the back being cleared away. Leave it five minutes longer still, for safety's sake. In hot weather, when the sensitised surface of the glass is apt to frill, the plates should be immersed in a 20 per cent. solution of alum, and rinsed, before fixing. Never use warm water. The developing dish must be used for developing only, and a separate dish used for fixing.

Now that the negative is developed and fixed, it must be washed, as the hypo has to be removed. Put it in a basin of water, which is slightly tilted under a tap, and keep the water running for at least thirty-five minutes. Don't turn on the tap too hard. There are specially-made dishes for washing, but a basin does quite well. The negative may be taken out of the dark-room for examination after it is fixed and before washing, but it should be washed as soon as possible, otherwise crystals will form on the surface. Remember that the sensitised surface is very easily scratched and spoilt by finger-marks. Hold the negative gingerly.

When the negative is washed, we lean it on a shelf against the wall to dry. At the end of five minutes we shift it slightly, as we find a small pool forming at the base of the negative. We must not print from the negative till it is quite dry. As a rule, a negative left over-night will be dry in the morning. If we wish to dry our negative quickly, we immerse it in methylated spirit for ten minutes, and it will be dry in half an hour.

Printing. In printing it is usual to begin with the paper called "P.O.P." There are dozens of good makes, and that with matt surface is more artistic and stands more knocking about than the glossy kind. The negative is placed in a printing-frame (costing about 5d.), glass side downwards. The prepared side of the paper (it curls inwards) is placed in contact against the upper (sensitised) side of the negative. An insertion at the back holds everything in position, and the frame is placed in the window-sill or open air to print. We follow the directions on the back of the paper we buy for the depth to which we must print. If we are to use the "combined toning and fixing" bath, we must probably print a little deeper than the picture which we ultimately expect, as a certain amount is cleared away in the solution.

The combined toning and fixing bath is simpler than the two separate baths, and, with care, can be made to produce almost as permanent results. But if we want really permanent results, we had much rather choose the more artistic process of carbon printing, described later on in this course.

If the combined bath is used, no preliminary washing, as a rule, is necessary. If we use the two separate baths, the prints must be immersed in water till it becomes milky. Formulæ for making up the solutions for the separate baths are supplied with the various kinds of paper. As each maker has his own formula, we do not repeat any here, so as to avoid confusion. After the bath, or baths, the prints must be washed for about an hour in running water, and always kept moving, as they will not wash properly if allowed to lie on the top of each other.

We find it much cheapest to buy our combined toning and fixing bath in powder form. The retail chemist will sell us this bath in bottles containing about 16 oz. for 1s., but we can make 32 oz., for instance, from the 1s. tin of the Agfa "neutral toning and fixing salts." If we wish to make up the whole of our own solution, a formula follows.

Combined Toning and Fixing Bath. Chloride of gold, 2 gr. (usually sold in tubes containing enough for five or six such baths, and costing about 1s. 9d. each); nitrate of lead, 10 gr.; chalk, ½ oz.; hypo, 4 oz.; water, 20 oz. Shake the solution, and use the clear portion when it has settled.

If we have only evenings to spare for printing we may try the gaslight papers. Here the exposure is made by holding the printing frame at a short distance from an artificial light, for some time, which varies according to the make of the paper. Follow the directions always attached to the cover of the packet. The paper is then developed as if it were a negative, in a developer such as ortol, which is conveniently made up from the tabloid brand of chemicals. This is cheaper than the gaslight developers sold by the makers of the various papers, and quite as good. After developing, the paper is fixed in a hypo solution and washed, just like a negative.

The self-toning papers should also be tried for the sake of variety. These, as a rule, require only to be fixed in a hypo solution, and often give artistic results.

Taking Portraits. Nothing is more difficult than to take a good portrait, either indoors or out of doors. But at the same time nothing gives us more pleasure when we have really succeeded. Very often the out-of-door snapshot gives the most living impression. But at the same time this is apt to lack dignity, and the portraits that give the most lasting pleasure have repose. The exposure for an interior portrait depends on the lighting of the room, and can be gauged only by experience. Try three seconds to begin with. In portraiture, especially with a cheap camera, the great danger lies in the perspective. The hands or the feet come out too large, and big feet are apt to end in bad tempers. The reason why the ordinary lens distorts is too elaborate to explain here. But it exists. The safest way of avoiding this distortion is to keep the sitter as nearly as possible in a plane parallel to the front of the camera. For instance, if we have a fascinating young lady in a

deck-chair, we do not plant her facing us, with her face towards us and her head leaning back, unless we wish her No. 3 shoes to appear in the photograph as larger even than her matinée hat. Rather place the chair sideways. A standing pose, as a rule, avoids distortion. The nearer the camera is to the sitter the more danger there is of a freak photograph. On the other hand, if we are too far away, we are apt to have the portrait too small. The Bond Street photographer gets over this difficulty by having an expensive "long-focus" lens. With our guinea camera we must select our poses to suit our short-focus lens. A maxim to keep in mind is: "Not too near, yet not too far."

The choice of background is very important. It must be remembered that the camera is apt to pick out more detail than the eye notices. So far as possible, it is advisable to look out for backgrounds that are quite simple, and do not interfere with the interest in face or figure. The colour of the background is also important. Greens and reds and yellows come out darker than we should expect. A background of green leaves in a garden picture is often disappointing for this reason. A little experience and observation will soon teach us what to avoid in this direction. In interiors, greys come out more as we should expect than do pure or vivid colours.

A Natural Pose. As to the attitude of the sitter, a natural attitude is far the most interesting even though it may not be found in any picture by Reynolds. Far too many "posey" portraits are made nowadays. We are apt to forget that the poses found in the great portraits of a hundred years ago were natural to the costume of the day. Modern dress suggests new graces. If we must study pictures for poses, we should rather go to a modern painter such as George Henry, A.R.A., whose portraits may be seen at the Academy or New Gallery, and are often reproduced. But, best of all is to do what the great portrait painters themselves have done, study Nature and the natural pose.

In portraiture, both indoors and out of doors, the value of backed plates (costing 3d. per dozen extra) is incalculable. The backed plate undoubtedly retains more detail and more subtlety of gradation than the unbacked. The cost is very little more, and anyone who once begins to use backed plates will very soon use no other. A camera in which backed plates are used requires most careful dusting, as the material used in many kinds of backing is apt to rub off, and ultimately produce spots, unless the camera is kept rigidly clean.

As already explained, the up-to-date cheap hand camera of to-day can be used with success for interiors as well as snapshots, as there are arrangements for time exposures and for the accurate focussing of near objects. Where the object is to show part of the room in which a person is sitting or working, the lens must be stopped down to at least "*f* 11," otherwise part of the picture will be out of focus. In a small room, or where there are near objects, a still smaller stop must be used. The value of the backed plate will be appreciated if a window or highly lighted article, such as a silver ornament, comes into the picture.

Hints for Development. If the picture flashes up too readily in the developing dish, and we suspect over-exposure, we can slow down the development by rapidly and gently wiping the surface with a piece of cotton-wool dipped in a 10 per cent. solution of potassium bromide. In developing negatives of interiors, we should always have this handy. Even in the case of backed plates, a window is nearly always over-exposed and shows hallation—a blurred appearance round the edge of a light object. With the cotton-wool and potassium bromide, we can arrest development locally. Our knowledge of negatives can be acquired only by experience, but the more we know, the more we value this power of local treatment in the earlier stages.

As the modelling of a face depends so much on infinitely slight gradations, the more detail we can keep in the negative the better. We can simplify afterwards, if we like, by the use of special papers in printing. But a negative is never the worse for detail. To secure this detail, slower development is advisable in the case of portraits and interiors. The developer may be weakened to half strength.

Our guinea camera has probably a "colour screen," a piece of yellow glass which may be inserted in front of the lens. This greatly improves a landscape photograph, and is especially useful for dull days. The exposure, however, must be increased three or four times in length, and isochromatic plates should be used.

Flashlight. We can take portraits in the evenings by flashlight. For these the ready-made flashlight candles may more safely be recommended than magnesium ribbon or powder. These require no apparatus, and are easy and safe to use. The tendency is to under-expose in the shadows, so that as much reflection as possible may be thrown on the sitter from newspapers or light wallpapers. The farther away from the sitter, the weaker is the light: but at the same time the light should be placed in a position so as not to fall directly either on the lens or on the eyes of the sitter.

In the case of portraits, vignetting can often be used with advantage. We can easily make vignetting cards for ourselves. We cut an oval or circle of a little less than the desired size out of a piece of dark coloured paper—for instance, the black paper in which P.O.P. is wrapped—then we snip round the inside edge of this circle or oval, and push up the edge made in this way into a sort of frill. We print with this frilled oval or circle in front of the frame. The frill softens the edges of the resulting vignetted picture.

Intensification and Reduction. By the time we have taken a few dozen negatives we realise that some are over-developed and too dense, and some are too thin. These can be remedied by "reduction" and "intensification," processes which are really very easy, though they entail the use of poisons.

For intensification, the solution most commonly stored by the chemist is the uranium intensifier. A better intensifier, which, however, must be handled with great care, as it is very poisonous, is the mercury and ammonia intensifier. This is used by most professional photographers, but will not be sold readily by chemists to young people. The negative is immersed in a saturated solution of bichloride of mercury—four pennyworth will go a long way, and it can be used over and over again—until it is bleached. It is then washed for at least thirty-five minutes in running water. We then immerse it in a very weak solution of ammonia—10 minims of strong ammonia to 10 oz. of water—till it is quite blackened again. All negatives must be thoroughly clear of hypo before intensification.

The cheapest, and in many respects the best of reducers is ferricyanide of potassium, a poison that must be handled with care. A pennyworth will go a long way. It is usually sold in small

crystals. One small crystal suffices for a quarter-plate dish of water. The negative need not be cleared of hypo before reduction, and a little hypo should be added to the solution. Watch the negative carefully. As soon as it is reduced to the required density, we wash it at once under a tap for half an hour and leave it to dry. A negative that is already dry must be soaked in water till the film is soft again before intensification or reduction. Negatives that have been dried with methylated spirit do not reduce or intensify so well as those dried in the ordinary way.

Enlargements by Daylight. When we have made some successful pictures with our guinea camera we are sure to become more ambitious, and anxious to make larger pictures. To do this it is not necessary to get a larger camera, but we can supplement our quarter-plate with an enlarging camera. There are two kinds of cameras for enlarging, one for daylight and the other for artificial light. A daylight camera which will enlarge from quarter-plate size ($3\frac{1}{4}$ in. by $4\frac{1}{4}$ in.) to whole-plate ($6\frac{1}{2}$ in. by $8\frac{1}{2}$ in.) can be bought for 7s., so the initial expense is not very great. We must, however, buy larger dishes for the larger size of paper. Two whole-plate dishes will be required, costing about 11d. each. A packet of twelve sheets of bromide paper, whole plate size, costs 2s. We can therefore roughly estimate the cost of each print at 4d. to cover the cost of the enlarger and the waste. In the daylight enlarger of fixed focus, enlarging from quarter-plate to whole-plate, the light passes through the negative and then through a lens, so that the image is projected upon the printing paper fixed at the other end.

Enlarging bromide paper is, as a rule, very sensitive to light, so that the packet should be opened and the enlarging camera loaded only in the dark-room. Those who have already mastered gas-light printing by contact will make successful enlargements at once, as the same kind of paper is used. The length of exposure depends on the strength of the light and the speed of the paper. Owing to the expense of waste, it is well to make test exposures in the camera with small pieces of paper before risking a whole sheet. The makers of paper now recognise this by enclosing an extra piece, quarter-plate size, which may be used for preliminary test. If we are used to the ortol developer, we may use it for our enlargements. If not, we may try amidol.

Formula for amidol: amidol, 80 grains (sold at 2s. per oz.); sulphite of soda, 2 oz.; water, 12 oz.; bromide of potassium, 15 grains.

This has to be made up fresh for each printing, and deteriorates in about two hours. The bromide of potassium makes the developer a little slower, but brightens the prints. A negative that may print rather thin and flat with P.O.P. may give bright prints in an enlargement if we under-expose and use a strong solution.

Artificial Light Enlarging. But by far the most satisfactory method of enlargement is by artificial light. Here our light is always of the same strength, whereas daylight is constantly changing. Another great advantage is that we can control the printing. For instance, we may have a negative of an interior lit up by a window or flashlight on one side. By placing a piece of cardboard in front of the thinner portions of the negative, we can to a large extent rectify this unevenness of lighting, and make a presentable print.

Another advantage about the artificial enlarging lantern is that it may be used as a magic-lantern, and we can amuse our friends by throwing our pictures on the screen.

The cost, however, of the artificial lantern enlarger is greater than the other, since a "condenser" or large lens for concentrating the light has to be used. This in itself is so expensive that a reliable enlarger can hardly be bought new for less than three guineas. We can, however, often pick one up secondhand for rather less. The photographer who wishes to go in for Press or professional portrait work later on will find this artificial light enlarger absolutely necessary.

In the enlarger for use with artificial light the light, which is usually an incandescent or electric light, preferably the former, is behind the condenser, and the condenser concentrates the light on the negative. Through the negative the light passes on to the lens, and the image is thrown into focus on bromide paper either fixed on a slide or pinned on a board fixed upright at the requisite distance. We require no elaborate stand for our enlarger, but can prop the spare leaf of our dining-room table against the wall of the dark-room and set the enlarger on two wooden chairs of equal height. An arrangement for focussing enables us to enlarge to any size or in any proportion we desire. If by any chance we have tilted our camera by mistake, and so got the lines in the wall of a house slanting, we can stop down the lens in the enlarging camera and tilt the support of the paper slightly so as to correct this awkward mistake. We can very often improve our negative by enlarging only the interesting portion of it. A sharp negative will enlarge many diameters without showing any trace of enlargement. Experienced tourists know this, and often prefer to take with them only a quarter-plate camera, knowing that they can enlarge their good negatives to any size at home.

Hints for Enlarging. The lens in the enlarging camera should always be stopped down a little as this tends to give a brighter print. The utmost care should be taken to keep the hands perfectly clean in printing, otherwise the paper will show stains. It is always advisable to "clear" an enlarged print, as the paper, especially if of glossy surface, is inclined to show markings, due in no way to the operator. This clearing solution is the same as the reducing solution (ferricyanide of potassium), mentioned already. Dip a piece of cotton-wool in this, and gently rub the surface of the paper while still damp. This will clear the whites wonderfully, and will even remove slight yellow stains due to previous carelessness.

We can focus accurately on the paper by placing in front of the lens a yellow glass cap which is removed for the exposure. These caps are stored by any dealer who has enlarging cameras. All white light, however, should be excluded from the room, as the bromide paper used for enlarging is sensitive to the light, far more so than is generally supposed. If we want to be sure of good prints, we must run no risks. Do not expose the print after development to any other than the light shown through this yellow glass till the print has been at least five minutes in the hypo (fixing) solution, or we risk getting it fogged.

Lantern Slides. Lantern slides are very easily made without special apparatus by contact printing. They are really positive prints made on glass instead of a paper support. We will probably find among our negatives a number in which a square of $3\frac{1}{4}$ in. makes a good picture. This is the size of the lantern-slide. Prepared plates for

lantern-slides are sold at 1s. per dozen, and the positive is made by contact in the same way as in the case of gaslight papers. It is, however, well to clear the slides for the sake of improved transparency after development and fixing, and before washing. Here is a well-known formula for clearing solution:

Protosulphate of iron, 3 oz. (sold at 3d. per lb.): alum, 1 oz. (sold at 2d. per lb.); citric acid, 1 oz. (sold at 2d. per oz.): water, 20 oz., or in proportion. The depth to which a lantern-slide should be developed can be gauged only by experience. If, however, we study a good lantern-slide such as we often see in an optician's window, or such as are sold for educational purposes, we can save ourselves much trouble and waste.

If we wish to secure the whole of our negative on our lantern slide we can still do so without special apparatus. We must block up the whole of a window lighting a room with dark-brown paper, leaving only a hole the size of our negative. Into this hole the negative is fixed, say, by means of sticking-plaster over the corners. We must now photograph this negative on a prepared lantern-plate, focussing accurately and getting the image as near $3\frac{1}{4}$ in. at its widest part as possible. We should stop down our lens to at least f 22, and back our plates with backing-paper, which may be bought at 6d. a box. The lantern-slide plates will fit into the sheaths of our camera, but must, of course, be fixed in the middle of the sheath, otherwise the picture may overlap the plate.

The positive plate has to be mounted before it is a complete slide, otherwise the film would be quickly destroyed by the heat of the lantern. Cover-glasses, made of very thin glass, and of the same size ($3\frac{1}{4}$ in. by $3\frac{1}{4}$ in.) are placed so as to cover the sensitive side of the positive, and the two glasses are bound together by binding strips round the edges. This binding is quite easy to do.

More Advanced Work. Although a great deal may be done with a quarter-plate combined with an enlarging camera, we may be pardoned if we grow still more ambitious. The average lens, even in expensive quarter-plate cameras has so short a focus that distortion is difficult to avoid. By "focus" we mean the distance in the camera between the centre of the lens and the photographic-plate. The human eye is said to have a lens corresponding to one of 16 in. focus, but the quarter-plate camera is satisfied with $4\frac{1}{2}$ in. or 5 in. It is, of course, possible with a focussing camera to adapt a telephoto lens, such as the "Adon," to overcome this objection, but for many reasons we should do better still with a good half-plate camera. It is a good plan to get a camera with a double anastigmat lens, in which the front and back portions of the lens (each of different focuses) can be used separately or in combination, giving us the choice of using short or long focus lens at will. Thus, a combined lens which has a focus of $6\frac{1}{4}$ in. may consist of a front portion with focus of 14 in. and a back portion with focus of 9 in. The camera that is to hold such a lens must, of course, have a bellows capable of extending to 14 in.

In the case of portraits, the longer the focus the better. A curious fact also is that a large lens seems to give more modelling and to get round the objects more than a small lens of the same focal length.

Carbon printing and the subsidiary processes so much affected by artistic workers are hardly worth attempting in less than half-plate size. It is, of course, possible to make enlarged negatives, and to print from these; but, after all, the best method of making enlarged negatives is by the carbon process itself.

Carbon Printing. The chief makers of carbon tissue—the Autotype Co., and Elliott & Sons supply such elaborate directions that it is unnecessary here to give more than a brief outline of the process. A good plan is to experiment with the Trial Set supplied by the Autotype Co., or the Sample Set supplied by Elliott & Sons.

The principle and method of carbon printing are so simple and the results so artistic that we can well understand why it has taken the foremost place both in amateur and in professional photography. We may begin by explaining how the image is made in the carbon tissue. It has been discovered that gelatin combined with bichromate of potassium becomes more or less insoluble according to the amount of light to which it is exposed. When a prepared gelatin tissue is exposed to the light under a negative it becomes insoluble in depths which vary according to the strength of the light which the negative allows to pass through its parts. A small amount of light passes through the whole of the negative, and therefore the whole of the surface of the tissue

A SUCCESSFUL SNAPSHOT

ENLARGEMENT OF SNAPSHOT ON OPPOSITE PAGE

(Observe the clearness of detail after enlargement)

is affected and becomes insoluble. The problem is, how are we to get to the lower layers of the tissue, so that we can dissolve away that which has not yet been affected by the light? This is done by transferring the tissue from the paper on which it is originally mounted to a new support, face downward. When this transfer is made, the soluble portions now exposed can be cleared off by the application of warm water, and the positive image —made of insoluble gelatin—brought to view.

The Single Transfer. In the single-transfer method of carbon printing—the simplest, and therefore the best to begin with—the image is reversed from left to right, but very often this does not matter. The sensitive tissue is usually made up twice a week by the companies that supply it, and should be used within nine days, as it does not keep. Prints should be made in dry weather only. The safe edge mask—supplied in the Trial Set—must always be applied round the edges, otherwise the transfer

is apt to be unsatisfactory. No image is seen at first in the printing, so that an actinometer for measuring exposures has to be used. A simple actinometer is supplied with the Trial Set. The time required for printing is considerably less than that for P.O.P., and the action of the light continues—at a reduced rate—after the tissue has been taken out of the frame. We may turn this continuing action to advantage in the case of prints which are suspected of under-exposure. If these are kept for twenty-four hours before development they may turn out all right.

The single-transfer paper is slightly larger than the mounted carbon tissue. It is placed face upwards in a tray of cold water at about 60° F., and all air bubbles must be carefully removed. We should have a depth of at least 1½ in. of water in the tray. Then the exposed tissue is placed face downwards in the water, and the fingers gently slid along the surface underneath to remove air bubbles. The tissue will flatten out, and then begin to turn up at the edges. The tissue and the transfer paper are now brought into contact under water and taken out together, and then squeegeed into perfect contact with a scraper squeegee, such as is supplied with the Trial Set. The two sheets are now put between blotting paper and laid under a heavy weight, such as a large book. This secures uniform pressure. All the prints are treated thus, and left under pressure for about half an hour, or till the back of the transfer paper is turned yellow.

Developing with Water. For development, two baking tins, costing about a shilling each, will do. But we must not use these tins afterwards for baking, as bichromate of potassium is a strong poison, and the success of our printing should make us desire to live a little longer. Fill this tray with water heated to 90° F. to 100° F. The gelatin soon begins to ooze out at the edges. Then transfer the sheets to a tray of slightly hotter water, 100° F. to 110° F., about 1½ in. deep. Holding the combined sheets under water, lift up a corner of the tissue sheet and gently strip it off. If it does not strip off readily, leave it a little longer and try again. The gelatin is now transferred to the new support, and the lower soluble layers are exposed and can be treated. The transfer paper, to which the tissue now adheres, is placed on a slab or flat dish at an inclined angle, and laved with water at 100° F. to 110° F. by means of a teaspoon. Gradually the image will appear as the soluble part is washed away. We lave it till it is a little lighter than we desire the finished print to be. The water can be kept at an even temperature by placing the tray on a gas stove with the gas jet at the proper height. If the tissue has been over-exposed it does not easily dissolve, and still hotter water must be used. This, however, must be used with care, as it is apt to cause blisters.

The great charm of carbon printing is that local development can be carried out so easily. A sky that would otherwise be lost can be saved by developing the upper portion of the picture in cooler water than the lower, and over-exposed portions can be reduced by careful laving with hot water, or the local application of sulphocyanide of ammonia—sold at 3d. per oz.

When the print has been sufficiently developed, it must be cleared and hardened. A filtered 5 per cent. solution of powdered alum in water is the bath. This clears away the yellow stain and hardens the film, after which the prints should be washed for half an hour in running water, and then hung up with clips to dry.

Double Transfer and Modifications. In the double-transfer method, a temporary support is used instead of the single-transfer paper, and from this temporary support the image is transferred to a final support. This double transfer restores the image to its natural position. For making enlarged negatives, a special transparency tissue is made, which requires half more exposure than the ordinary kind. This is transferred by the single-transfer process to a glass support, and printed through an enlarging camera on to a negative of the size required. The image is reversed to its natural position by keeping the tissue side of the glass towards the source of light.

Modifications of the carbon process avoid transfer, but usually require us to sensitise our own solution. On the whole the old method is the most satisfactory of all printing processes, and we do not grudge the slight extra trouble.

The Press and the Editor. Photography for the press contains more of the element of uncertainty than any other branch of the craft. If we are actually on the staff of a paper, this uncertainty is, of course, diminished, but between the freelance and success a thousand chances intervene. Still, it is one of the most interesting, and often one of the most profitable forms of using the camera. A very skilful and successful photographer for the press acknowledges that after paying all expenses, he clears about £500 a year. It must be remembered, however, that he is at the top of the tree, and has fifteen years of hard work behind him.

The main point to remember is that we cater not so much for the public as for our editor. We must give him the kind of print and subject he wants, not what is intrinsically best. Very often we shall find our best work thrown on our hands, owing to his personal tastes, or the space he may have at his disposal. "Better luck next time," we must say, and try again.

In the first place, it is advisable to make our prints not less than half-plate size, and with a glossy surface, which may even be squeegeed. The reproduction the editor may make may be only 3 in. by 4 in., but he personally likes to see the prints large. For this reason, most Press photographers use a half-plate camera, so that they can readily run off contact prints, and in many cases they print through the enlarging camera on glossy bromide paper, submitting pictures whole-plate size. The glossy surface is not really necessary for reproduction, and some engravers actually damp the paper to get rid of the gloss before making their block; but few editors know this, and prefer the print which apparently shows most detail. There are, of course, exceptions, and "Country Life," for instance, takes artistic photographs even on rough surfaces. This extreme, however, is only possible in the case of a magazine with exceptionally fine printing.

Camera for Press Work. The most convenient all-round camera to use is a light, folding half-plate camera with focal plane shutter, giving exposures down to 1,000th part of a second, and either slides or a magazine containing 12 plates. Our outfit will cost us about £20. The lens should be able to work well at $f/6{\cdot}3$, or if possible, $f/5$, and the finer the lens the more likely we are to achieve success under all conditions of weather. We must be prepared to make bright, contrasty pictures at seven in the morning on a rainy day. One of the most successful press photographers uses a lens with 10 in. focus, but this requires more experience

in accurate focussing than, say, a Goertz-Anschütz with lens of 7 in. focus. Some get over the difficulty by having both a long and a short focus lens. This, of course, requires a camera that can be adapted to different lenses. It must be remembered that, especially in sporting photography, we have to snap at a distance from the object required, and yet our figures must be as large as possible. We do not recommend the reflex type of camera for general work. Many of the most skilful photographers do not even use a finder, but gauge by experience the view taken by the angle of their lens, and point the camera breast-high at the person or object required. In snapshotting celebrities, this is often the only practical method. We have to keep our eye glued to our victim, and at the same time have the whole field in view, otherwise we may miss the characteristic attitude, or someone will step in front at the critical moment. In a crowd we may even have to hold our camera above our head.

A SUCCESSFUL SNAPSHOT OF ACTION

In addition to the snapshotting of news events, there is also the vast field of magazine work. Skill in portraiture is also a great advantage, as the illustrated newspaper of to-day becomes more and more personal in its interests. One successful photographer has made a speciality of doing for the press artistic portraits of celebrities at home or in their natural surroundings. The chief London photographers naturally acquire numbers of portraits which are in demand with editors. So much is this the case that they sometimes have to retain a special staff for running off prints for the press.

Celebrities. So much are celebrities photographed nowadays, that few copyrights are worth more than ten guineas at the outside. The usual fee for reproductions of photographs of any sort by an illustrated paper is 10s. 6d. per print for reproductions up to 6 in. by 4 in., and a guinea beyond that size. Reduction in price is frequently asked and granted for a series or set of photographs, but the half guinea is a useful standard, fair alike to editors and photographers. Occasionally an editor

ENLARGEMENT OF THE SNAPSHOT SHOWN ABOVE
(The detail is so good that every face shows up like a portrait)

will offer to buy exclusive rights in a photograph for a definite period, when we may get from one guinea to ten guineas. Such occasions and such editors are rare.

Chance, of course, may turn a portrait into a goldmine. Thus, the photograph made by Elliott & Fry of General Baden-Powell, a few days before he started for the war, was reproduced in millions; but in these days of peace a new photograph of this hero would not get much more than five guineas in copyright fees, if so much.

Advanced Flashlight. The Press photographer must be master of flashlight work, as the subjects required—especially in magazine work—have often to be taken under difficult lighting. A small room may be lit up sufficiently by magnesium powder, or a flashlight candle, but it is advisable to know how to manipulate more powerful flashlights. There are several kinds of explosive powders used in advanced flashlight work, but the safest, and at the same time one of the most brilliant, is *argentorat* (price 5s. for 4 oz.), which has the merit of not being set alight by percussion. It is so highly inflammable that it must be handled with great care, and must not be lighted with a match held in the hand. Also, it must not be used in a closed lamp, such as is used with magnesium powder, but in an open metal tray. A handy portable lamp for use with these special flashlight powders is the Weiss lamp (price 30s.), in which a match, close to the powder, is ignited by pulling a string. Another lamp ignites the powder by means of an electric spark.

So vivid is the light of a powder such as argentorat that people jump out of their seats, and they should therefore be cautioned in advance that there is no danger. The flash is so rapid that the photograph is taken before the movement occurs. The smoke is, unfortunately, a great nuisance, and our flashlight may occasionally bring up the fire brigade on a false alarm. Scrape the ash carefully off the tray after each flash, otherwise your later flashes will be accompanied by loud explosions.

Enlarging is particularly valuable in the case of snapshot work, where we are often compelled by circumstances to stand too far from the desired object. We can amend this by enlarging only the important part of the negative.

Sale and Speed. Country photographers often find it convenient to sell prints through the press photographic agencies. These send representatives round the chief editorial offices, charging 15 per cent. to 25 per cent. commission. In the case of news photographs, where there is no time to run off many prints, these agents are very handy, as one editor may have special reasons for refusing good prints, for which another has space.

In the case of news pictures, speed is half the battle. Pictures of an event that happens on a Monday morning should be submitted, if possible, the same afternoon. Methylated spirit of good quality enables one to dry prints and negatives rapidly. P.O.P. prints can be made rapidly by the developing process. In this the paper—which should be put in the frame in a dark-room—should be printed only till the detail in the high lights is faintly shown, and then developed in the dark-room with a black developer such as hydroquinone (not pyro), treated all the time with the same care as a negative.

Mr. C. F. Bowden, of Bowden, Bros., perhaps the most skilful sporting photographer in this country, has kindly sent us the following hints for those who intend going in for such work.

1. Get your figures as large as possible. Avoid having a heavy background of trees when taking fast exposures. They look artistic in the finder, but don't reproduce well owing to under-exposure.
2. Don't keep changing your brand of plates. Start with a good make, and use only the fastest for extreme exposures. It does not do to use the slower, and cheaper make, as the results cannot be obtained with these.
3. When developing, avoid using too much ruby light. The less the better.
4. Don't be impatient with very fast exposures when developing. Anybody can press the button and take a picture in a 1,000th part of a second; but it is not everybody who has the patience to develop a plate for an hour or two, as is often the case in winter.
5. A lens working at a large aperture, say f/5·6, is essential.
6. Don't press the shutter release on camera with a jerk.
7. Rehearse in your mind what you are going to do; and when the moment arrives, do it.

Professional Portraiture. The best guide to those who intend to take up professional portraiture is naturally one who has himself succeeded. Mr. E. C. Elliott, of the firm of Elliott & Fry, gives some practical advice on the subject. "Don't try at first to get into a big London house," he says. "Get into a good moderate-sized provincial house where everything is done under one roof. At Elliott & Fry's, for instance, every department is specialised, and it would be difficult for one to get that general grasp of a business which is essential for a man who intends eventually to set up for himself. After one has realised what one is best fitted for, one may decide to specialise, for instance, as an operator or a printer, a retoucher, or finisher. The Professional Photographers Association has started an excellent system of certificates of merit for assistants, awarded after examination. If you decide to set up for yourself, you must be up-to-date and a little bit before it. I don't know that it is advisable to start with a partner. Partnerships are very uncertain things, and I think that, at any rate to begin with, a clever man with a capable staff can manage by himself. Wherever you are, you must adapt yourself to your locality. A seaside or suburban photographer has quite a different clientele from that of Elliott & Fry, and yet may do excellent business. The things to remember are, that whatever your kind of photography may be, you should try to be good of your kind, and that you should not cut prices. You must be up-to-date in the getting up of mounts, in your printing methods, framing and displaying, while such small details as price-lists, packing of pictures, labels and notepaper should be studied, with a view to making them as attractive as possible. Every young professional photographer—in fact, every photographer young or old—would do well to become a member of and support the Professional Photographers Association, and so have at his disposal in all matters of difficulty which may arise the help and advice of a committee of the most experienced men in the profession. Much friction and litigation is avoided through the good offices and advice of this committee in the many delicate and sometimes complex matters that are brought before them by members. If you obtain a standing which enables you to obtain celebrities as sitters, you must be absolutely scrupulous as regards copyright both towards your sitters and towards the editors."

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Group 15
HISTORY
47

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HISTORY OF OUR OWN TIME

The Rebellion in Canada The Corn Laws. Some Great Statesmen. The Crimean War. The South African War. China and Japan

By JUSTIN McCARTHY

THE reign of Queen Victoria began on the morning of June 20th, 1837. The young queen, born on May 24th, 1819, was, at the time of her succession, little more than eighteen. The Queen's first Prime Minister, Lord Melbourne, was a man of great personal kindness, but with slight gift of statesmanship, and Queen Victoria was obliged from the first to exercise her own good sense in the direction of affairs.

Among the leading men in political life were Lord Brougham and Lord Lyndhurst in the House of Lords, and Sir Robert Peel, Lord John Russell, and Daniel O'Connell in the House of Commons. Among the earliest events of the reign were the development of the railway system throughout the country, the application of the electric current to conveying messages along the wires, and the use of steam for ocean navigation. The Melbourne Administration did not last long, and was succeeded by that of Sir Robert Peel. The Queen, in opening Parliament, on January 16th, 1840, had announced her intention of marrying her cousin, Prince Albert of Saxe-Coburg-Gotha, and the marriage, which took place on February 10th, proved a most happy union.

The Rebellion in Canada. The opening of the reign saw the great rebellion in Canada.

The Canadian Colonies had been divided by an Act called the Constitution of 1791 into Upper and Lower Canada. Upper Canada was inhabited chiefly by a British population and Lower Canada by a population of French or French descent. Each of the provinces had a governor and an Executive Council appointed by the Crown, a Legislative Council, also appointed by the Crown for life, and a Representative Assembly, the members of which were elected almost altogether through the influence of the ruling authorities.

The two provinces, at heart hostile to each other, agreed only in hatred of the absolute rule of a British sovereign and Government in far-off Westminster. The memory of the American Revolution was still fresh in Canada, and it stimulated French Canadians especially into an effort at armed rebellion. The arbitrary measures employed by the Canadian authorities to subdue the rebels only made their resistance more serious, and won the support of Upper Canada. The rebellion probably might have been crushed by the Canadian authorities, but such a result would only have sown the seeds of further risings. Fortunately there were statesmen then in the British Parliament able to see that Canada could not be made loyal by military force. Lord John Russell introduced a measure to suspend for a time the constitution of Lower Canada, and to send out from England a Governor-General and High Commissioner empowered to deal with the rebellion and to remodel the constitution of Upper and Lower Canada.

Lord Durham, who had been in more than one Administration and was known as an advanced reformer, was entrusted with this office. He invited the two provinces to join him in forming a new system of government, and framed a constitution which united the two provinces into one colonial system, representative and self-governing in colonial affairs, thus founding that principle on which all of England's great colonies have since been conducted. Lord Durham returned to England, and the measure, in substance, was passed in 1840.

The Opium Traffic in China. In the opening of the Queen's reign there were disturbances in China between the government of that country and some of the British trading companies, which led to the Opium War. These troubles had been going on before Victoria came to the throne, and were caused by the policy of preceding sovereigns. British traders, under the old East India Company in the first instance, had insisted on importing opium into China and selling it to the Chinese in defiance of the laws of the Chinese Empire, which made its sale a punishable offence. The Queen's Ministers were endeavouring to end this odious traffic, when the disputes between the Chinese authorities and the opium dealers led to the outbreak of war, causing much loss of life on both sides.

The British ships of war, and the British soldiers soon gained the ascendency, and the Chinese government had to give way. Peace was made on the conditions that the Island of Hong-Kong should be ceded to Britain, and that five ports, of which Canton was the most important, should be thrown open to British traders, and that an indemnity should be paid to England for losses incurred. The Government explained that England could not interfere for the purpose of enabling British subjects to violate the laws of China, and that any loss such persons might suffer from the execution of the Chinese laws must be borne by those who brought that loss upon themselves. This announcement had been made before the actual outbreak of the war, and the war was carried on to its end.

The Afghan War. The Afghan War cast a gloom over the opening of the reign. Afghanistan is inhabited by various tribes each ruled by its own chief, and all in frequent rivalry and conflict among themselves. The Government of Queen Victoria was brought into Afghan trouble through the medium of the East India Company, which became involved in one of the disputes among Afghan states and unwisely sustained the claims of one of the rivals who were contesting for sovereignty over the state of Cabul, and for something like supremacy over the other divisions of the country.

The greatest figure in the struggle was that of Dost Mahomed, a man of remarkable ability both in war and in peace, and who professed to be, and indeed appears to have been, a friend to England. The Governor-General of India, however, resolved to treat Dost Mahomed as an enemy, and the English Government was thus drawn into a policy which brought about his conquest and dethronement. His rival, Shah Soojah, entered Cabul, the capital city of the state, by the help of British officers. He was regarded there as a usurper, and when the British army afterwards withdrew, leaving only a small force behind it, Dost Mahomed renewed his efforts, and in November, 1840, opened a brilliant campaign. Knowing, however, that he could not withstand the power of England, he gave himself up

to the English commander, by whom he was treated with courtesy and honour and was sent to India under British protection. There was an immediate outbreak in Cabul, and in the tumult that arose a brilliant English soldier and traveller, Sir Alexander Burnes, was murdered. Akbar Khan, the favourite son of Dost Mahomed, became a leader of a movement against Shah Soojah. The English general, seeing that the situation was hopeless with the small force at his command, entered into a treaty, the effect of which was that the British troops should quit Afghanistan at once, and that Dost Mahomed should be brought back from India.

The Retreat from Cabul. During negotiations a fierce controversy broke out between the British commander, Sir W. Macnaghten, and Akbar Khan, in which the latter, who afterwards declared that he believed he was about to be captured by the British troops, shot Macnaghten dead. It was agreed that the British should leave the Afghan territory. Then began the disastrous retreat of the English through the mountain passes between Cabul and the Indian frontier, during which they were constantly assailed by fanatical native tribes, and the wives and children of the officers and soldiers suffered terrible privations. Few of the military force reached the Indian frontier alive. Under the rule of Lord Ellenborough, the new Governor-General of India, the losses which had been undergone by England were repaired, and on September 15th, 1842, Cabul was again occupied by the British troops. On October 1st, Lord Ellenborough issued a proclamation, revoking the policy of his predecessor, and declaring that to force a sovereign upon a reluctant people would be inconsistent with the principle of the British Government, and that the British arms would be withdrawn from Afghanistan. Dost Mahomed was soon after released from exile, and became once again the ruler of Cabul, and Shah Soojah, whom the policy of England, as directed by the East India Company, had set on the throne, was put to death shortly after the departure of the British troops by orders of the Afghan chiefs.

Sir Robert Peel's Government. The Administration of Sir Robert Peel was made remarkable by many reforms in social legislation. An Act of Parliament prohibiting the employment of women and girls in mines and collieries was carried, chiefly through the influence of Lord Ashley, afterwards the Earl of Shaftesbury. Many reforms were made in the conditions of factory labour, in which Lord Shaftesbury also bore a prominent part. Sir Robert Peel also passed the measure for removing the test by means of which Jews were excluded from some municipal and other public offices. The most famous of Peel's reforms was the Abolition of the Corn laws, which imposed heavy and indeed prohibitive duties on the importation of foreign grain into England. A great movement against these restrictive laws had been got up by the Free Trade party, which became very strong in Manchester and throughout the North of England.

The movement was for many years led by Charles Villiers, but its most powerful promoters were Richard Cobden and John Bright. Richard Cobden was one of the most convincing debaters the House of Commons has ever known, and John Bright must be ranked among the greatest of England's parliamentary orators. Sir Robert Peel had not yet become a convert to the principles of Free Trade. The Whig party, led by Lord John Russell, did not at the opening of the anti-corn law movement give it their full adherence, but they soon accepted the principle and Sir Robert Peel was gradually brought round to the same position. The outbreak of a potato famine in Ireland forced Peel's hand, as it became evident that without the most liberal introduction of foreign grain the peasantry of Ireland must die off. Peel could not force some of his colleagues to accept a Free Trade principle, and he resigned. Lord John Russell was sent for by the Queen to form a ministry, but even amongst his Whig friends he could not obtain sufficient support, and the Queen urged Sir Robert Peel to withdraw his resignation. The Free Trade movement had the full support of Daniel O'Connell, because of its bearing on the condition of Ireland.

Peel formed a new ministry, and Parliament met on January 22nd, 1846. On the 27th Peel brought in his measure for the gradual abolition of the protective duties on grain, which were to be abandoned altogether after three years. The Bill went through the House of Commons, passed its third reading on May 15th, and was then carried through the House of Lords mainly by the earnest advice of the Duke of Wellington, who saw that the change to Free Trade was inevitable.

The Irish Famine. A vast number of deaths from starvation greatly reduced the population of Ireland, and the dread of another famine and the unjustifiable enactments which secured to the landlords absolute power over their tenantry caused a rush of emigration to the United States, to Canada, and to other British colonies, which reduced the population still more. When the famine broke out the population of Ireland numbered some 8,000,000, but between that time and our own it became little more than 2,000,000.

Ireland was inevitably much disturbed by the famine, and the tardy movement of remedial measures caused much trouble among the Irish peasantry. Peel was prevailed upon by some of his colleagues and supporters to introduce a Coercion Bill, with the object of restoring order in Ireland. The Prime Minister thus put his Government into a most critical situation. The Coercion Bill would be met with unyielding opposition by O'Connell and his followers; the Whigs, when out of office, usually opposed coercion unless when accompanied by promises of concession and reform. The English Radical members, under the leadership of Cobden and Bright, would be sure to oppose coercion even more strongly: while the disappointed Protectionists were willing to vote for once with the Radicals, the Whigs, and the Irish Catholics, because the Government had turned against them on the Free Trade question. The division on the second reading of the Coercion Bill on Thursday, June 25th, 1846, left the Peel Ministry in a minority of 73. Within three days Peel resigned, and was succeeded by Lord John Russell as First Lord of the Treasury, with Lord Palmerston as Secretary for Foreign Affairs. Peel's career as a statesman ended with his great triumph in the repeal of the Corn Laws. He did not return to office, and on June 29th, 1850 he met with injuries which caused his death.

Famous English Statesmen. Lord John Russell, Lord Palmerston, and Mr. Disraeli were the most prominent among English statesmen during the immediate following years. Lord Palmerston devoted his attention mainly to foreign politics, and was a moderate Liberal in his views on home affairs. He was an admirable debater, although hardly an orator. Lord John Russell held more advanced views on home politics and was more cautious in his dealings with revolutionary and anti-revolutionary movements abroad. Disraeli was one

of the most brilliant figures in the House of Commons and was famous as the author of political novels before he entered Parliament. During some early attempts to obtain a seat in the House of Commons he declared himself a Radical and a supporter of O'Connell's Irish policy. When he succeeded in the object of his ambition and found a constituency to elect him he had become a strong Conservative.

Lord John Russell's Titles Bill was introduced in February, 1851, because of a Papal Bull authorising the establishment in England of a Hierarchy of Bishops deriving their titles from their own sees. The Pope had divided England into several districts, to which he appointed archbishops or bishops, with Cardinal Wiseman as Archbishop of Westminster. Lord John Russell denounced the action taken by the Pope as a pretension of supremacy over the realm of England, and brought in his Ecclesiastical Titles Bill accordingly. Parliament opened on February 4th, 1851, and soon after Russell introduced his measure to prohibit the use of all such titles by Catholics under penalty, and to render null and void all bequests made to or acts done by persons under such titles. The Bill passed through all its stages with some modifications, but the Roman Catholic archbishops and bishops still took their titles as before, and the Act was never put into force.

The Crimean War. The Crimean War was mainly the result of Russia's growing power in Europe and in the East, which was believed by many European statesmen to be a danger to Powers which, like England, had interests to guard in Asia as well as in Europe. The growth and the political ambition of Russia became a menace to Turkey especially, and, indeed, threatened the Ottoman Empire with ultimate destruction. The immediate cause of dispute between Russia and Turkey had to do with the manner in which Christians from Russia, Greece, and from other countries were treated by the Mohammedan ruler of Turkey. An alliance was formed between England and France, then under the rule of Napoleon III., with the object of compelling Russia to modify her policy of aggression against Turkey.

Austria and Prussia took a part at first with England in forming this alliance, but Prussia withdrew at an early stage of the arrangements, and Austria never became an active partner, although she continued to exert some influence. Sardinia, one of the small separate Italian states, eagerly grasped the opportunity of taking a part in European affairs by becoming a member of the Alliance. Turkey declared war against Russia, and then England, France, and Sardinia took the field. There was splendid fighting on both sides, many great battles like that of the Alma and of Balaclava, and the prolonged siege of Sebastopol. There was a want of generalship among English and French alike: no soldiers ever fought better than those of England and France, but there was a sudden and almost complete breakdown in the arrangements made for the food and clothing of the English troops. The services of the newspaper war correspondent created during this campaign an era in the history of warfare. They kept the world informed day by day of the events of the war, and compelled the attention of the authorities in England and France to the want of needful preparations for the health of the troops.

Another memorable event of the Crimean War was the splendid movement originated by Florence Nightingale in organising a little army of nurses to attend to the wounded in the field.

Sebastopol. The war came to an end by the capture of Sebastopol, which the Russians had set on fire before abandoning. The Emperor Napoleon was anxious to get out of the whole enterprise, and a congress was held at Paris on February 26th, 1856, and on March 30th the treaty of peace was signed. By this treaty Sebastopol and all other places taken by the Allies in the war were given back to Russia. The Sultan issued a decree to improve the condition of his Christian subjects, the Black Sea was neutralised, and the navigation of the Danube was thrown open. Two of the Sultan's Christian provinces, Moldavia and Wallachia, while continuing under the nominal rule of the Porte, were to be guaranteed the rights of citizenship, and out of these two provinces grew the kingdom of Roumania. The results of the war were hardly worth to England the blood and treasure it had cost. Sardinia gained the most, because the position she had taken as an ally enabled her to put herself forward as the representative of the whole Italian people. The Crimean War was still fresh in the memories of Englishmen everywhere when the great Indian Mutiny broke out, the story of which has been told in another place.

The close of 1861 brought with it the death of the Prince Consort, and after his death the Queen withdrew almost altogether from social life.

The year 1868 saw the conclusion of the celebrated British expedition into Abyssinia. This expedition was organised because of great alarms felt in this country as to the fate of a large number of British subjects held in captivity by Theodore, King of Abyssinia, who chose to consider that England had become unfriendly to him. All efforts failed to induce Theodore to surrender his prisoners, and at last the British Government made preparations for war. An expedition organised under the command of Sir Robert Napier was admirably planned and carried out from first to last. It had little danger to meet in the way of armed opposition, for there was no Abyssinian force which could hold out against the British troops. The expedition was a complete success, and reached the front of Magdala in the beginning of April, 1868. Theodore was ultimately compelled to restore all the prisoners in the hope of saving his capital and himself; but he would not surrender, and Sir Robert Napier felt that he could not leave other British residents at the mercy of such a monarch. Despite the immense difficulties of its position, Magdala was captured, and when the gate was forced open the dead body of Theodore was found inside. Napier destroyed the fortress of Magdala, and no attempt was made to interfere further with the internal affairs of Abyssinia.

Trouble in Egypt. The winter of 1881 saw the opening of new troubles for England in Egypt. At that time Egypt was under what was called the dual control of England and France, each of which states had done much fighting to secure its interests there, while the Ottoman Sultan still held a nominal control over the nominal sovereign or Khedive. Egypt was governed almost altogether by English and French officials, and the result was the formation of an Egyptian national party under the leadership of Arabi Pasha, a brilliant Egyptian officer.

He had been appointed War Minister under the Khedive, but soon became really master of the Egyptian Administration. It was evident that an Egyptian rebellion against the dual control was springing up, and the ironclads of England and France were ordered to Alexandria. The Khedive endeavoured to dismiss Arabi Pasha, but the leaders of the

army refused to obey his order. Arabi Pasha seemed as if he were already beginning preparations for war. Disturbances broke out in Alexandria, and some English and French subjects were killed, for which Arabi Pasha was undoubtedly indirectly responsible. As France did not seem disposed to interfere, the English authorities determined to act. An attack was made upon Alexandria by the British Fleet, and a bombardment began. Then Arabi Pasha hoisted a flag of truce, and without waiting for any negotiations withdrew his soldiers from the fortifications, and Alexandria was occupied by the British. There was still some fighting to be done, and Sir Garnet Wolseley was sent to command the operations. Arabi entrenched himself at Tel el Kebir, but the British advance was made so rapidly that the struggle was over almost as soon as it began. Arabi was made a prisoner and sentenced to death, but the sentence was commuted by the Khedive to a sentence of banishment. The dual control soon vanished after this, and England has since occupied Egypt.

The bombardment of Alexandria by the British forces led to the retirement of John Bright from the Gladstone Cabinet, because he could not agree with the policy of using force for the coercion of Egypt.

The Boxer Movement. Great troubles broke out in China in 1898 which compelled the active intervention of England. The increasing immigration of foreigners into China aroused a passionate clamour amongst the Chinese against the modern policy which allowed foreigners to hold property there. A powerful party of reactionary Chinese, called the Boxers, sprang up all over the country, which made it a first object to banish all foreigners from China. Many outrages were committed by the Boxers on Christian missionaries, and the American missionary buildings near Pekin were burned. The foreigners formed an allied squadron of vessels—English, German, French, Russian and Japanese—and these were compelled in self-defence to fire on the Chinese forts, which had opened fire on them, and to capture and hold the forts. Actual war had set in by this time between the Chinese and the foreign Powers, and its outbreak was precipitated by the murder of the German Minister, Baron von Ketteler, in the open street, by a civil officer of the Chinese Government. The foreign Powers were compelled to enter into an alliance, and an expedition was got under way from Tientsin on August 4th, 1900. The combined forces were British, French, Germans, Russians, Americans, Italians, and Japanese, numbering little more than 20,000 men. The allied troops had to fight their way to Pekin, the Chinese troops, who were well supplied with artillery, fighting from behind entrenchments. They reached Pekin, forced an entrance, and on August 26th the city was surrendered, and a detachment of the Allies marched through the capital to proclaim their victory. The Chinese Government were compelled to make peace with the Allies, and amongst the conditions was the infliction of severe punishment on Chinese even of high rank, convicted of having encouraged the attacks upon foreigners. It was also stipulated that some reform should be made in the methods of Chinese government concerning the admission and protection of foreign residents.

War With South Africa. The struggle for the suzerainty of the Transvaal Republic spread over more than twenty years of Queen Victoria's reign, and was only brought to a head in the reign of King Edward VII. The Transvaal Republic had been founded by Dutch Boers, or farmers, in 1848, and thus became a state in the neighbourhood of the great British settlement in South Africa extending to the Cape of Good Hope. The policy of the English Colonial governors in South Africa was directed towards the forming of a federation of all the states and of the Orange Free State, another colony also founded by Boers, to be held under the protection, and, in fact, the sovereignty of England. The Transvaal Republic resisted these proposals, and was afterwards joined by the Orange Free State, and war broke out, in which the Boers fought pertinaciously, and with many advantages on their side.

The Struggle in the Transvaal. The English had to conduct the invasion of the Transvaal, a region of vast extent, broken by great mountain ridges and vast swamps, in which the Boers could always choose their own points of defence and compel their adversaries to follow them. The English had an incalculable advantage in the number of their force, and in all the means of carrying on the war; but the difficulties in their way were so many and perplexing that at one time it seemed as if nothing less than the extirpation of the whole fighting population of the Boers could end the struggle. In December, 1880, the Boers proclaimed the Republic of South Africa with Paul Kruger as its President. During the night of February 26th, 1881, took place the engagement at Majuba Hill, in which the English troops, under General Colley, were defeated and their general killed. General Sir F. Roberts was then sent out to South Africa, but in the meantime the Boers had, with characteristic prudence, proposed an armistice, and afterwards expressed a willingness to enter into terms of peace. A treaty of peace was agreed upon early in August, the terms of which were that the Transvaal territory should be assigned to the Transvaal state, but that that state should be subject to the suzerainty of Queen Victoria, who was to be represented by a British Resident. This arrangement met with extreme disfavour among large numbers of influential Englishmen at home, who argued that England never should have consented to enter into terms of peace with an enemy after a defeat had been inflicted on the arms of England.

The Jameson Raid. The South African question was destined to be yet a source of trouble. The discovery of gold and diamond mines in the Transvaal region had brought a rush of settlers from all parts of the world, and from England in particular, and a large population had soon established itself in the Transvaal to whom was given the expressive name of Uitlanders, or Outlanders, who claimed votes and recognised citizenship in the Transvaal. President Kruger and his Government insisted on obtaining conditions of residence which, though not very severe in themselves, led to much agitation among the Outlanders. An invasion of the Transvaal by a number of the Outlanders was actually undertaken, under the leadership of Dr. Jameson, in 1895, but the invaders were met by a large force of Boers and compelled to surrender. Events now drifted rapidly towards a renewal of the war between England and the South African Boers, and in December, 1899, Lord Roberts, one of England's most famous generals, was sent out to take command. The war lasted for three years. The difficulties in the way of any rapid conquest were just the same as those which met the British commander and troops in the former Transvaal war.

The relief of Mafeking by the English troops

excited a tremendous enthusiasm through England. The Orange Free State was conquered and annexed, and then President Kruger, realising that all hope for the Transvaal was gone, fled from Pretoria, the capital, which was entered by Lord Roberts on June 5th, 1900. There were some further struggles and a long period of negotiations. The Dutch offered concessions from time to time which the British Government refused to accept, but it had become apparent to everyone that the actual war was over. A peace conference was held in May, 1902, in Pretoria. The British terms were unconditional surrender and the annexation of the Transvaal and the Orange Free State to the British Empire, but with the right of these states to local self-government, and the undertaking that no death penalty was to be inflicted on any of those who had fought in defence of the South African States. England has since allowed to the Transvaal its full power of local self-government, and it holds now a position like that of Canada or one of the Australasian colonies.

Some Great Reforms. The reign of Queen Victoria was essentially a period of reform. The system of transportation for convicts found guilty of any crime making them liable to a penalty short of capital punishment was abolished in 1857, and the system of penal servitude and tickets of leave, which had been extending its application became definitely set up in its place.

The reign was distinguished by reforms of all kinds—in constitutional and political arrangements, in jurisprudence and its workings, in the application of medical science, in financial systems, in universities and colleges and schools, in art and letters. We have already described the movement for the introduction of Free Trade in corn, and there had been more lately a commercial treaty with France accomplished mainly by the intelligence and the persuasive powers of Richard Cobden during the reign of Napoleon III.

The principle of religious equality was developed during the reign of Queen Victoria in a manner which makes the reign an era in England's history. Flogging in the army was abolished after years of agitation by a small and enlightened minority in the House of Commons. The Divorce Court has been set up and the old-fashioned, enormously expensive procedure through the House of Lords has become one of the curiosities of past history. In the political world we have had many great reforms, some of which have almost entirely cleared the air from the foul atmosphere of bribery and corruption which for many generations suffused our narrowly limited electoral system. Great political changes during Queen Victoria's reign were made by Conservative as well as by Liberal administrations. Disraeli having, as the leader of the Conservatives, defeated a very moderate Liberal measure of Parliamentary reform, introduced, when he became Prime Minister, another measure going much farther. Gladstone, at the head of a Liberal Ministry, introduced more lately the measure which set up the political system we have now in existence, practically establishing manhood suffrage.

Gladstone's Home Rule Bill. In 1886 Gladstone, once again in power, became convinced that the Irish Nationalist Party, the large majority of the Irish members of Parliament, were really the spokesmen of Ireland's demand for Home Rule. He brought in a measure for the creation of a statutory Parliament in Ireland, which was defeated on its second reading by the Conservative Opposition, with the help of many dissentient Liberals, and Mr. Gladstone, having appealed to the country, was defeated also at the General Election. But at the General Election of 1892 the Liberals, with the Irish Nationalists, secured a majority over the Unionists, and in 1893 Gladstone's second Home Rule measure passed through the Commons, but was thrown out by the House of Lords. Since that time the Irish National movement has been growing steadily in strength and in popular acceptation.

On January 22nd, 1901, Queen Victoria breathed her last. With her death the longest reign recorded in England's history came to an end. She was the first really constitutional sovereign who had ever occupied the English throne, and was succeeded by her eldest son, Albert Edward, known as Edward VII.

CHINA AND JAPAN

China and Japan were, in Queen Victoria's reign, beginning to break out upon the world in quite a new light. Europe was during many centuries brought into occasional intercourse with China, and England had especially been brought during many succeeding generations into conflict with the rulers of the Chinese Empire. But Japan had remained a state in absolute seclusion from the European world, just as she had been from the opening of her history. Suddenly, in 1867, a revolution broke out against the feudal system, which had hitherto ruled Japan, and with the success of that revolution the progressive party which came into power reversed all the traditional ways of the Japanese people. Japan seemed to have undergone a new birth. The passion of the Japanese now was for everything new, for everything belonging to modern Europe and to the United States: for the newest methods of political government, the newest developments of science and letters and art, the newest fashions and fantasies. The first railway in Japan was opened in June, 1872. Telegraph wires were soon conveying their flight of messages over the whole country and from the country abroad. The fine arts and the letters of Europe were studied everywhere with avidity.

A New Power in the Far East. But it was not only in the arts of peace that the Japanese began to take a sudden interest. Japan appeared to be inspired by a desire to become proficient in the knowledge and the practice of the modern warfare, and in these the Japanese showed themselves marvellously successful. Japan became entangled in a war with China for the over-rulership of Corea, and the Japanese unquestionably had the best of the struggle. From that time it began to be apparent to the whole world that Japan was determined to emerge once for all from her long seclusion and to become a conquering power. She adopted the principle of constitutional representation, and on July 1st, 1890, she opened her first national Parliament. But Russia at this time began to prove herself a determined opponent to the spread of Japanese influence in the Far East. Russia, although, strictly speaking, one of the European Powers, was, because of her vast Siberian territory, growing civilisation, and rapidly developing railways, making her influence widely felt throughout Asia. A power determined to rise like Japan was sure to come sooner or later into antagonism with Russia. This is what happened, and the result was a war which the whole world watched with keen anxiety. The outcome was a complete victory for Japan, and it then became evident that a new power had arisen in the Far East.

Concluded

SHOOTING AND FIXED STARS

Continued from page 6579

Atmospheric Bombardment. Nature and Constitution of the Stars. How Starlight takes Years to Reach the Earth. The Universe a Disc. Cosmical Evolution

By W. E. GARRETT FISHER

METEORITES, or shooting stars, have been known to mankind from the earliest times, though it is only of late years that their intimate association with comets has been discovered.

Aerolites. Shooting stars must be divided into two classes. There is the solitary *fire-ball* or *aerolite* [**40**], which sometimes assumes very respectable dimensions, like that which burst over Madrid a few years ago, or that which once strewed the plains of Arizona with vast masses of meteoric iron. These visitors can never be predicted, though few nights in the year pass without one or more of them being visible to the careful watcher of the skies. They are masses of rock, chiefly consisting of pure iron, which collide with the earth as it travels through space, but are fortunately prevented, as a rule, from dashing against its surface by the convenient buffer interposed by the atmosphere. The resistance of the air, which is practically experienced by cyclists struggling with a head wind, increases very rapidly with the velocity of a body moving through it. It is the most serious factor in the flight of a modern projectile, and a meteorite which enters the air with a velocity of many miles per second is promptly raised to such a temperature by the atmospheric resistance to its motion that it is rendered incandescent and dissipated into vapour or dust, unless its size is very great. In the latter case it breaks up into a number of small pieces, with a flash and a report which is sometimes heard on the surface of the earth, and these pieces may ultimately reach the ground.

Many specimens of such aerolites are to be seen in the Natural History Museum at South Kensington; the Sacred Black Stone of Mecca and the image of Diana, which was said to have fallen from heaven at Ephesus, are believed to be the remains of such meteorites. But, as a rule, visitors of this kind are entirely consumed in the upper regions of the air. The *luminous streak* which they leave behind them as we watch them on a clear night is composed of their disintegrated dust raised to incandescence by the friction of the air. This dust slowly settles down upon the surface of the earth, and is frequently met with in the ooze of the deep seas and among the sands of the deserts. It has been estimated that between 1,000,000 and 2,000,000 of these shooting stars are encountered by the earth in every twenty-four hours. If it were not for the atmosphere we should be bombarded by these projectiles in a fashion far more perilous than any known to Ladysmith or Port Arthur.

Star-showers. In addition to these solitary and mostly invisible aerolites, the earth encounters meteor swarms which are of periodical occurrence. The most conspicuous and famous of these are the November meteorites, known as the Leonids, which used to give rise to a wonderful display of celestial fireworks once every thirty-three years. From very early times men have recorded the fears produced by the contemplation of this wonderful and brilliant onset of stars shooting madly from their spheres. In 1833 the negroes of the Southern States were quite persuaded that the end of the world was at hand. The sky was said to be as full of shooting stars as it is of snowflakes in a winter storm [**41**]. They reappeared in 1866.

Something has recently gone wrong with these Leonid meteorites, and the display which was confidently expected about 1899 never took place. There are several hundred of these meteor-showers known to astronomers, and hardly a week in the year passes when one or more of them is not due. Each shower is recognisable by the fact that it seems to come from a particular place in the heavens, and it is usually named after the particular constellation from which it comes. Thus the two chief November star-showers are the Leonids, coming from the constellation of Leo, and the Andromedes, coming from the constellation of Andromeda. A star-shower due about the 10th of August, popularly known as the Tears of St. Lawrence, consists of the Perseid meteorites, coming from the constellation of Perseus. The point from which any particular star-shower appears to come is known as its *radiant*, and is found by tracing the path of each observed meteorite upon a star chart; the point in which all these paths meet—their vanishing point—is the *radiant point* [**42**].

Meteoritic Swarms. Many of these star-showers occur year after year on the same night, whilst others, like the November Leonids, occur on the same night at intervals of many years. There is only one plausible explanation of this fact.

The shooting stars which become visible by contact with our atmosphere on a particular night in the year must belong to a swarm of such bodies travelling round the sun in a definite orbit, which intersects the orbit of the earth at the point which our planet reaches on that night. At every meeting a considerable number of these minute bodies are sacrificed by contact with the earth, but their number is so great that there seems to be no appreciable diminution in it. If the meteoritic swarm be distributed with evenness along the whole of this orbit, there will be a display of shooting stars of pretty much the same brilliance every year.

In the case of meteorites like the Leonids, which only appear once in thirty-three years, the main body of the meteorites must be concentrated into a swarm which travels round its orbit at such a speed that it only passes the earth's orbit while the earth is in that neighbourhood once in thirty-three years. The explanation of the failure of the Leonids to appear when they were last due is that some external cause has changed their motion by perturbing their orbit so that now they just miss the earth. The orbits of a considerable number of these meteorite swarms have now been calculated—a wonderful achievement when we remember that they can only be studied in the brief instants in which they are burnt up by the contact with our atmosphere.

A Comet is a Meteoritic Swarm. Soon after the great shower of November meteorites in 1866, it was shown by an Italian astronomer, Schiaparelli, that the orbit which has been assigned to the Perseids or August meteorites was identical

with that of a comet which had been observed in 1862. Soon afterwards the orbit of the Leonids or November meteorites was also calculated, and it also turned out to be identical with that assigned to a comet which had been discovered by Tempel in 1866. Next the Andromeda meteorites, which meet the earth in the latter part of November, were found to move in the track of Biela's comet. Since then at least five other meteoritic swarms have been found moving in orbits coincident with those of comets.

It is impossible to suppose that all these coincidences are accidental. It is now believed that a comet is simply a meteoritic swarm, and that when it disintegrates—as more than one comet has been seen to do—it breaks up into a crowd of meteors, which tend to be scattered gradually more and more thinly along its orbit, until in the lapse of time there results an orbit covered from end to end with a thin ring of flying meteorites. These meteorites are mostly quite tiny bodies—mere specks of cosmic dust—though some are sufficiently large, as we have seen, to endure the intense heat which they undergo in passing through the atmosphere and still reach the earth as a solid mass. There is good evidence that at least once or twice many tons of solid iron have thus been precipitated to the earth; fortunately for our comfort, such evidences are rare, and are not known to have occurred in historic times.

The Fixed Stars. We have next to study the nature and constitution of the so-called *fixed stars*. Our sun is a body of the same kind as the stars, of which about 3,000 are visible to the naked eye in our hemisphere, and many of which are, in reality, far larger and brighter than our luminary. Yet their vast distances make them appear only sparkling points of light—for no telescope that man is ever likely to make can be expected to reveal the physical features of any of the fixed stars. The spectroscope, however, has told us nearly as much about their chemical construction as about that of the sun, while the telescope and spectroscope, with the gravitational theory, have revealed the most wonderful facts about their movements.

The fixed stars are arranged for convenience in certain groups or constellations, of which about eighty-six are recognised. Most of these constellations date from times when the heroes and totems

40. METEORITE FOUND IN OREGON IN 1902
(From "Knowledge")

of early civilisations were placed in the sky by a race living in the Euphrates Valley; many of them were afterwards modified to suit Greek mythology. The particular stars of each constellation are denoted by the Greek letters of the alphabet, Alpha, Beta, Gamma, etc., beginning with the brightest. Where it is necessary in telescopic work to deal with a greater variety of stars, they are given numbers or indicated by their place in some catalogue of stars. The brightest of the stars have also names of their own, like Sirius and Aldebaran.

The stars are classified according to their brightness in a series of *magnitudes*. On the original and rather rough scale, a star of any given magnitude is about two and a half times brighter than the average star of the magnitude immediately below it. There are twenty stars of the first magnitude, which differ greatly in brightness. Sirius is more than fourteen times as bright as Regulus, but both stars are called of the first magnitude. Stars of the sixth magnitude are the faintest normally visible to the naked eye. The more exact photometric methods of modern astronomers have led to more exact classification by tenths, and even hundredths of magnitudes, and in the case of the brightest star a negative magnitude has been introduced; thus Sirius, the most brilliant of the fixed stars, is said to be of magnitude $-1{\cdot}58$. A typical first magnitude star is Betelgeux, in Orion. The stellar magnitude of the sun, on this scale, would be about -26.

Parallax of the Stars. The prime fact about the fixed stars is that they are all situated at gigantic distances from the sun and from one another. For a long time the strongest objection to the theory of Copernicus was that if the earth really changed its place by an annual translation of more than 180,000,000 miles, the stars would have an altogether different appearance in perspective when the earth was at opposite ends of its orbit. The truth is that some of them do look differently to us at intervals of half a year, but the diameter of the earth's orbit is so tiny in comparison with the distance of the nearest star that any change in the apparent configuration of the stars caused by our motion from end to end of it is quite imperceptible to the naked eye, and can only be measured by the most accurate observations with powerful telescopes.

Some of the stars thus display an *annual parallax*, or show a slight difference in direction, according to which end of the earth's orbit we are looking from. The annual parallax of a star is, as already explained, equal to the angle which would be subtended at that star by twice the distance between the earth and the sun. But there is no star in whose case this parallax would amount to as much as a single second of arc. As Miss Clerke puts it, the annual shift of no known star amounts to as much as the width of a sixpence held up at Charing Cross and seen by an observer at Stanhope Gate or Millbank. The difficulty of measuring quantities of this nature is obvious. The most delicate instruments and the most refined handling are necessary for tackling the problem. Yet it has been successfully solved in the case of a fair number of stars.

The Unthinkable Distances of the Stars. Stellar distances, as will now be seen, are so gigantic that we are forced to measure them in terms of some different unit from that ordinarily used in computing distances. The nearest star is 275,000 times as far away as the earth is from the sun. Even this distance, if set forth in miles, would be quite unrealisable. To measure the distance of a star in terms of its parallax, though perfectly convenient for astronomers, has two objections for popular use, since the distance varies inversely as the parallax, and the latter has always to be expressed in small fractions of a second. Consequently, the unit which has been generally adopted for expressing the distances of the fixed stars is that known as the *light-year*. This is the distance over which light would travel in a year.

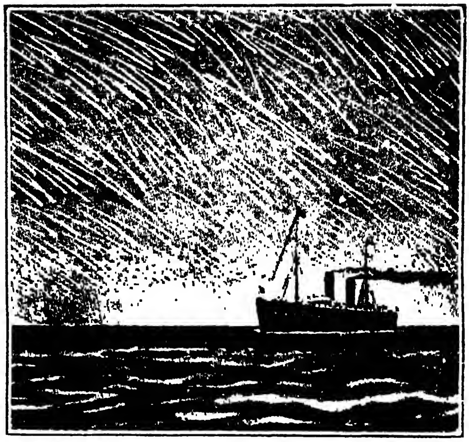
This distance can be computed in miles by multiplying the number of seconds in a year by the speed of light—186,330 miles per second. It is more useful to know that the light-year is 63,243 times the mean distance of the earth from the sun, over which light passes in 449 seconds. Thus the light-year is to the distance of the earth from the sun almost exactly as a mile is to an inch. A star with a parallax of one second is at a distance of 3·26 light-years from the earth. To find the distance of any star from its parallax we can use the simple formula $d = \frac{3 \cdot 26}{p}$, where d is the distance in light-years and p is the parallax in seconds. The nearest of all stars is the brightest star of the constellation of the Centaur, Alpha Centauri, which has a parallax of 0·76 seconds, and is consequently at a distance of 4·3 light-years from the sun.

The Scale of the Universe. Let us try to get a rough practical idea of what this means. Suppose we are making a model of the solar system and the stars. Let us start by taking a swan shot $\frac{1}{8}$ in. in diameter to represent the sun. The earth will be represented by a tiny speck of dust 1 ft. distant from this central globe. The superior planets come at distances varying from 5 ft. in the case of Jupiter to 30 ft. in the case of Neptune, the outermost planet. Some of the periodical comets travel out a good deal further into space—perhaps as much as 200ft. or 300 ft. But in order to get the nearest of the fixed stars into our model, we have to travel out for 50 miles before we reach its place on the same scale.

This will give the student some idea of the amazing isolation of our system. There is good reason to suppose that the average distance of the stars from one another is on pretty much the same scale. Some of the most conspicuous and brilliant stars, such as Canopus, Arcturus, and the bright star Rigel in Orion, have yielded no perceptible parallax, which means that their distance can be in no case less than 110 light-years. Among the nearest stars to the earth are Sirius (8·6 light-years), Procyon (10·9), Fomalhaut (23·3), and the Pole Star (44). The determination of stellar parallaxes is one of the most difficult tasks an astronomer can undertake. Photography has greatly helped in it, but as yet there are little more than 70 stars whose parallaxes are well determined. These, however, afford a scale for judging the size of the universe, and it has been estimated that the smallest stars visible in the most powerful modern telescope may some of them be at such a distance that their light would take more than 30,000 years to reach the earth —that is, in the model already described they would have to be placed farther away than the moon!

How History might be Lived Again. We may just remind the reader that this means, among other things, that if such a star were to be destroyed to-day by some catastrophe its light would continue to shine upon us for 30,000 years, and only at the end of that period would astronomers notice its disappearance. When we look at the star-strewn heavens, we are really gazing not only into the depths of space, but also into the dark backward abysm of time. We see the moon not as it is now, but as it was a little more than a second ago; the brilliant Dog Star shines on us with the radiance which lit it more than eight years before to-night.

Some of the other stars, and those among the brightest, we see not as they are now, but as they were at the time of the Spanish Armada or the Norman Conquest. A French astronomer has made a very interesting and perfectly sound deduction that a disembodied spirit which was able to move instantaneously through space to any distance from



41. METEORITIC SWARM

the earth, and was also able to see things clearly through any distance, could at will actually see any event which has taken place on the earth since the beginning of its history—at least, in the open air and under a clear sky—by simply travelling out to the distance to which the light rays carrying the picture of that scene have now advanced.

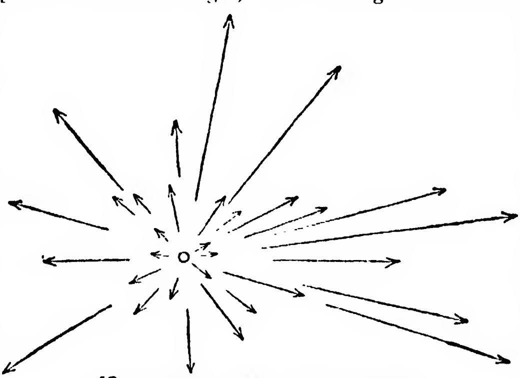
The Real Magnitude of the Stars. Having grasped the conception of the immense distances which separate us from the fixed stars, we are now in a position to see that these stars must in reality be gigantic suns. Wherever we can measure the distance of a bright star, we can make a rough calculation of its size by comparing its light with that given by the sun. We see at once that many stars must in reality be very much larger and brighter than our sun. Sirius, for instance, is at a distance of rather more than eight light-years; if the sun were removed to this distance, it would only give one-thirty-sixth as much light as Sirius gives, and we consequently infer that Sirius is thirty-six times as powerful a light giver as the sun. There are, of course, two factors in such a result. Sirius may either be very much bigger or very much brighter than the sun. We shall see directly that in many cases we are able to measure not only the brightness, but the mass of a star.

Some of the other stars are far larger still. Arcturus, which is about 126 light-years away, must be at least a thousand times as luminous as the sun. Canopus, the second brightest star in the sky—never visible in our latitudes—has shown no parallax at all, wherefore it must be well over 100 light-years away. At that distance our sun would shrink to a star of the tenth magnitude, absolutely invisible to the naked eye, and it can be calculated that Canopus is equal to at least 22,000 suns lumped together. No doubt many tiny telescopic stars, sunk in infinite space, are really still more brilliant and gigantic stars. Our own sun, in short, must be regarded as quite a second-rate member of the starry host.

The Motions of the Stars. Many stars not only show the annual shift of a fraction of a second which is due to parallax, but also change their position very slightly from year to year in consequence of their *proper motion*. There are two ways in which this motion can be measured. One is by the actual displacement of a star on the celestial sphere. About a hundred stars are now known which thus move a second or more per

annum. Such a displacement is perfectly measurable by modern instruments, though it only means that in about 2,000 years such a star would move over a distance equal to the diameter of the full moon. The star which has the greatest proper motion yet known moves over about eight seconds in the year. It is, unfortunately, invisible to the naked eye. If we know the approximate distance of such a star from the earth, we can, of course, calculate its actual velocity.

Runaway Stars. Thus, the extraordinary discovery has been made that the gigantic Arcturus is flying through space with a velocity of 257 miles per second—about 14 times that of the earth. What makes this so extraordinary is that the gravitational theory tells us that a star flying at such a speed cannot possibly be checked by the united gravitation of the whole known universe. It cannot be moving in an orbit, as almost all the heavenly bodies do, but seems to be engaged in a headlong rush through space, traversing the universe as an express train dashes through a wayside station. There are a few other stars of which the same thing has to be said. But, as a rule, the motion of the stars turns out to be similar in kind to that of the earth itself. Where their paths have been noted for a series of years, they generally prove to be not straight, but curved—parts of some vast orbit, which, in many cases, we are able to calculate, as will be shown when we come to speak of double stars.



42. RADIANT OF A STAR-SHOWER

There is a more modern way in which motions of the stars can be measured with even more accuracy. Of course it is not the case that all the stars which we see moving on the face of the heavens travel at right angles to our line of sight. Their paths lie in all possible directions, and all that we see of them is their fore-shortened projection on the imaginary sphere of the heavens. It will be apparent that a star which happens to be travelling straight towards the earth would not seem to be moving at all. But the spectroscope, among its numerous aids to astronomers, enables us to measure a star's motion in the line of sight with remarkable accuracy. This is in virtue of what is known as *Döppler's principle* [see page 3260], which may be briefly explained here.

Measuring the Stars' Velocities. We have already seen that the spectroscope breaks up the light given by any star into a series of lines, each of which has a defined place corresponding to the gas which gives birth to it. This is due to the fact that light of any particular wave-length is refracted to a definite extent. But suppose that the luminous object is travelling toward the spectroscope. The result will be that the light which it emits will reach the spectroscope with its own speed plus that of the moving body. Consequently, a greater number of light-waves will reach the prism in a second than would be the case if the luminous object were at rest. This causes a shift of all the lines in the spectrum through a distance which, though very minute, is capable of being measured with sufficient accuracy to reveal the stellar velocity in question.

The principle is exactly the same as that by which, when an express train dashes through a station, whistling all the time, the note of its whistle changes in pitch as it passes the observer. When the engine is approaching, a greater number of sounds reach the ear in every second, and the pitch of the whistle seems higher than it would be if the engine were at rest. When the engine has passed, the number of sound impulses in a second is diminished, and the pitch of the whistle drops noticeably. In the same way, the lines in the spectrum of any star shift towards one end or other, according as the star is travelling towards us or from us, and the amount of shift is proportional to the star's velocity in the line of sight. In this way, the speed of many stars towards or from the earth has been measured, and the combination of these two methods of measurement in many cases gives us, by composition, the actual speed and direction of the star's motion.

The chief result of such investigation is to show that there is no such thing as rest in the universe; every star that we can examine is in motion, and this, of course, is perfectly in accordance with the teaching of dynamics, which tells us that no such thing as a state of absolute rest can exist. All the stars which mutually attract one another are moving in vast orbits, with the exception of the few runaway stars like Arcturus, which seem to have come from the outer void of space and to be hastening back to it again.

Multiple Stars. One of the first discoveries of the telescope was that many of the stars which seem single to the naked eye really consist of two or more, very close together. The first double star discovered was the middle star in the tail of the Great Bear, which shows to great advantage, even in a small telescope. Another very fine double star, easily visible, is Castor, in the Twins. More than 12,000 of such pairs are now known. It is, of course, possible that a pair of stars, apparently so close together that they blend into one to the naked eye, may really be separated by a distance of many light-years, since they happen to lie in the same line of sight but at very different distances from the earth. But by far the greater number of double stars are physically connected pairs, which revolve in an orbit round a common centre of gravity.

Measurements made with the spectroscope show a double shift of the lines, which can only be due to the existence of two stars moving in opposite directions. In many cases this shifting of the lines has been observed to change periodically, so that the actual period in which the two stars complete their orbit can be accurately measured, though neither of them is ever visible separately. As an example of a typical double star, we may take Alpha Centauri, which consists of two stars nearly equal to our sun, which complete a very elliptical orbit about their common centre of gravity in about 81 years. Sirius, again, is the visible member of a double star, and has a companion of half its own mass, but 4,000 times less luminous, the pair completing their

orbit in about half a century. Not only double stars, but triple, and even higher, combinations exist in the heavens. In many cases these associated suns have strongly contrasting colours, which make them very beautiful objects in the telescope, and must create extraordinary conditions of vision for the possible inhabitants of a planet which happens to circle round one of them. Blue, green, red, and yellow stars are sometimes found, all associated together in a single system.

Colours of the Stars. Even with the naked eye we can see that the stars vary in colour. Some, like Aldebaran, Antares, and Betelgeux, are fiery red; others, like Vega, near the Pole, shine with a bluish lustre. Others, again, like Sirius, are white with a bluish tinge, while the majority shine with a yellowish-white light like that of our sun. There is good reason to suppose that these different colours indicate a different stage of stellar evolution, the bluish-white stars being th hottest, the red stars being comparatively old and cool, while the yellow stars, like our sun, hold a middle place. Telescopic stars often show much more brilliant colours than any which are visible to the naked eye, shining with sea-green and lilac, gold and azure, orange and emerald. These colours are usually found in compound stars, and not infrequently are found to vary from time to time.

43. PRÆSEPE STAR CLUSTER

Variable Stars. A great number of stars shine with a fluctuating or variable light. Observation has divided them into many classes. There are some in which the change is regular and recurrent. The best example of this type is Algol, the Demon Star, which falls from the second to the fourth magnitude once every three days, and is now known to be partially eclipsed by a vast dark satellite which revolves round it in that period. Another type is that of Mira, the Wonderful Star, whose light varies in a cycle of 333 days from below the ninth to nearly the second magnitude. At its weakest, it is quite invisible to the naked eye, while at its maximum it is quite a conspicuous star. Variability of this type is shown to be due to a periodical conflagration in the star. What causes this we do not know, but it is possible that this remarkable behaviour is somewhat analogous to the behaviour of the spots on our own sun, which is itself a very slightly variable star with an eleven-year period. There are several other classes of periodically variable stars which need not be described here. There are other stars which vary without regularity or warning, such as Eta Carinæ, which is normally invisible to the naked eye, but has been known on several occasions to burst out with a blaze which made it one of the most brilliant stars in the heavens.

Temporary Stars. There is no real distinction between irregularly variable and *temporary* stars. The latter, which create great interest among the public as well as among astronomers, are stars which once in history burst out into a sudden blaze, and then again shrink down to their former insignificance. The earliest recorded of these was seen by Tycho Brahé, in 1572, when a star which outshone even Venus and Jupiter suddenly blazed out in Cassiopeia. Within the last few years there have been well-known outbursts of the same kind in the constellations of Auriga and Perseus. Spectroscopic analysis has made it quite clear that in all these cases what we see is a veritable conflagration. Vast outbursts of incandescent gases suddenly well up from the interior of a quiescent and comparatively faint star, and raise it to a degree of luminosity which may rival that of vast and steady globes like Sirius or Vega. But such a star lacks the energy to keep up this output of light, and before very long dies away to its former faintness.

How the Earth might be Burnt Out. It has been supposed that the collision of two stars, or the falling of a vast planet into a tiny sun, might account for some of these sudden outbursts of light. Such an occurrence would certainly produce a blaze visible all over the heavens, but the collision of two stars is so improbable an event, in view of their vast distances apart, that we may eliminate it, and the falling of a planet into a sun has not as yet been known to occur. Probably it is bound to happen as systems grow old and decayed: it will certainly happen one day in our own system. But the behaviour of our own sun shows that the evolution of incandescent gas from a star's interior is quite a normal incident in stellar life. If the vast eruptions of glowing hydrogen which are daily emitted from the sun's surface were increased tenfold by some interior convulsion, the sun itself would blaze out as a temporary star—and, incidentally, life would be burnt off our planet. We can only say that the great majority of stars shine with fair regularity, and hope that the sun will continue to do the same.

44. A NEBULA

Clusters of Stars. A number of stars are arranged in clusters of groups, whilst others, like our own sun, are at vast distances from their nearest neighbours. Some of these clusters, of which the Pleiades afford the best example to the naked eye, can be resolved by a keen eye into separate stars: some, like Præsepe in Cancer [**43**], which only show to the naked eye as a hazy spot of light, break up in a good field-glass into clusters of stars; but the majority of stellar clusters require a powerful telescope for their resolution.

It was long ago noticed that the more powerful a telescope was, the greater was the number of these hazy spots of light which it would resolve into clusters of stars. Consequently the opinion was formed that all the hazy little clouds or *nebulæ* [**44** and **45**] which are so prevalent throughout a large part of the sky were simply clusters of stars, so far away that their light merged into a single impression on the eye. A great number of these nebulæ were only resolved by large telescopes, such as Lord Rosse's 6-foot reflector. But a great many of these nebulæ were found to be irresolvable by any telescope. It was simply concluded from this that they were still more distant than the clusters which had yielded to the resolving powers of the telescope, and it was further supposed that each of these clusters of stars might be a separate universe or galaxy, comparable in extent and importance with our own universe, bounded by the vast girdle of the Milky Way.

This grandiose conception of innumerable universes scattered throughout space was speedily destroyed by the spectroscope. As we have seen, the spectroscope distinguishes with entire certainty between the light sent to us from a solid star and that emitted by a gas. When it was turned upon the nebulæ which had been supposed in reality to be star clusters so distant that no telescope could resolve them, it showed unmistakably that these nebulæ were not star-groups, but simply masses of incandescent gas.

The Structure of the Universe. At the same time improvements in the methods of measuring parallax caused astronomers to revise their somewhat exaggerated notions as to the distance of the faintest visible stars. They have, in consequence, mostly given up the theory of innumerable universes in which the fancy of an earlier generation was pleased to run riot, and have formed a fairly coherent though still somewhat vague idea of the actual structure of the universe, of which a short account must now be given in conclusion.

The most casual inspection of the starry heavens shows that the visible stars are very irregularly distributed. Some regions are crowded with stars, whilst others show a very sparse distribution of orbs visible to the naked eye. The telescope, whilst vastly increasing the number of stars up to about 30,000,000 visible to the most powerful instruments, still emphasises the irregularity of their distribution.

The Galaxy. There is one region of the sky which is far more thickly strewn with stars than any other. This is the luminous belt which surrounds the whole sky nearly in a great circle, which is known as the Milky Way, or the Galaxy. To the naked eye it usually seems to be a luminous cloud, though on a very clear night it is possible for keen eyesight to make out here and there the brightest of the individual stars which compose it. The telescope and spectroscope agree in showing the Milky Way to be composed of innumerable stars, mostly of the eighth magnitude or smaller, and set so closely together that the whole belt of sky which they inhabit seems to be luminous [**46** and **47**].

The Milky Way contains very numerous clusters of stars, but very few gaseous nebulæ. The rest of the sky nowhere contains any such crowding of stars as is found in the Milky Way, though here and there we find a bright cluster, like Præsepe, where several thousands are condensed within a space much smaller than the full moon. The stars frequently seem to run into streams and groups, but on the whole their distribution is irregular and their number small in comparison with those of the Milky Way.

The Milky Way an Illusion. There is only one hypothesis which at present gives any reasonable explanation of this distribution of the stars. We cannot believe that the stars which form the Milky Way are really crowded together so closely as they look. The Milky Way is purely an effect of perspective. If we suppose the stellar universe to have the form of a vast flat disc, something like a crown piece, of which the diameter is much greater than the thickness, and our own sun to be situated somewhere near the centre of this disc, a little thought will show that we should get

45. THE GREAT NEBULA IN ANDROMEDA
(From "Knowledge," reproduced, by permission of Mrs. Roberts, from a photograph by the late Dr. Isaac Roberts, F.R.A.S.)

substantially the same appearance as has been described. When we look along the plane of this disc the line of sight travels through thirty or forty times as many stars as when we look up or down at right angles to the plane of the disc, provided that the stars are distributed in all directions with fair equality. Consequently to an observer near the centre of the disc there will appear to be a nearly circular belt thickly strewn with stars, whilst the rest of the sphere is much less thickly set with stellar orbs.

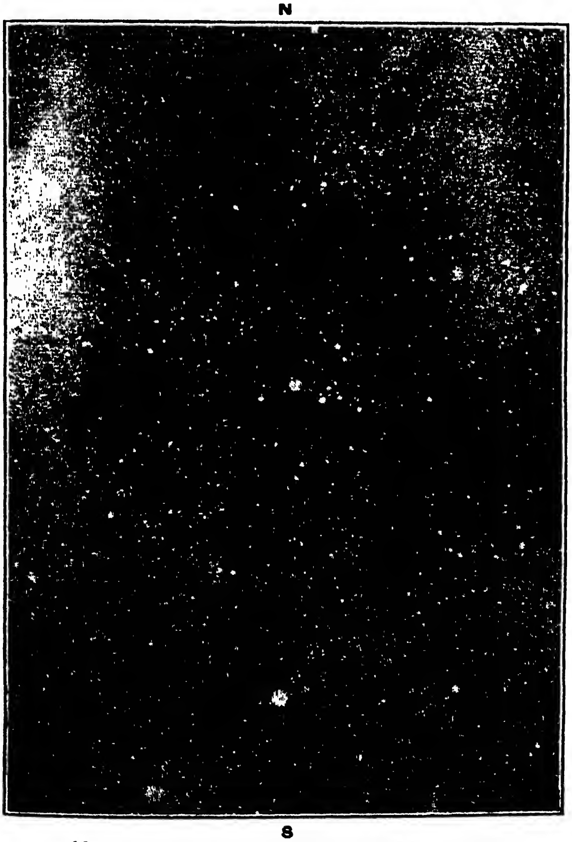
It is now generally held that this is roughly the arrangement of our stellar universe. There are many modifications in detail, based on the distribution of various kinds of stars and on the details which form the Milky Way, but these must be studied in more elaborate works, such as Miss Clerke's "System of the Stars." It is enough to say here that the probability is that our sun is near the centre of the stellar universe; that this universe consists of at least 100,000,000 stars comparable to our sun, but many of them vastly brighter and more massive; that these stars are arranged roughly in the shape of a circular disc of which the diameter is many times greater than the thickness; that the central part of this disc, near which our sun is situated, is much less thickly set with stars than the outer parts; and that its diameter is at least so great that it would take light 30,000 years to cross it.

The Nebular Theory of the Universe. It remains to add a few words as to the theory now accepted of the development of this universe and of systems like our own. We have seen that bright stars are divided into various types, according to their different spectra and colours. Some of them are undoubtedly hotter, and therefore younger, than others, and it is practically certain that there are many stars in the void of space which have grown cold and dark, so that we can never see them, though in some cases we are able to infer their existence from their gravitational influence on the neighbouring bright stars. Further, the universe contains a great number of *nebulæ* [**44** and **45**], which are merely clouds of incandescent gas. It was first suggested, by the great philosopher Kant, that these nebulæ might be the raw material of suns with their attendant planets. The physical conditions dominating the history of such nebulæ have been fully worked out by several generations of mathematicians.

The Birth of a Solar System. Suppose that we have a nebula or cloud of incandescent gas some 5,000,000,000 or 6,000,000,000 miles in diameter. This nebula must be subjected to two distinct causes of change. In the first place, all its material particles must attract one another by the law of gravitation, so that the nebula tends to condense towards the centre; and simultaneously, the incandescent particles which compose the nebula are constantly radiating heat out into space, so that the nebula must always be losing heat. On these two facts Laplace and his followers erected a complete theory of stellar evolution. Such a nebula cannot for a moment remain at rest, even if, which is exceedingly improbable, it was originally in such a condition. It would necessarily acquire a rotation about an axis, in addition to the movement through space which it would have under the influence of external gravitating bodies.

It has been shown mathematically that such a rotating nebula, losing heat at the same time and condensing inwards, would at regular intervals shed rings from its substance, and that these rings would tend to break up and coalesce into roughly spherical bodies or planets, which would revolve round the centre of the whole nebula and at the same time rotate on their own axes. Each of these rotating masses, if still hot enough to preserve the nebulous condition, would repeat the history of the original nebula, in turn shedding rings, which would coalesce into secondary spheres or satellites. Each of these derivative or secondary nebulæ, being much smaller than the parent nebula, would cool much more rapidly, and might become a solid body whilst the original nebula was still in the state of fiery gas.

This is believed to be the general history of the origin of the solar system, although further research has thrown doubt on some of Laplace's ideas. Once it was a vast cloud of fiery gas stretching beyond out the orbit of the farthest planet. As it contracted, it shed rings, which broke up into planet after planet, each with its own satellites. Neptune and Uranus came first; then Saturn, where the first anomaly appeared.

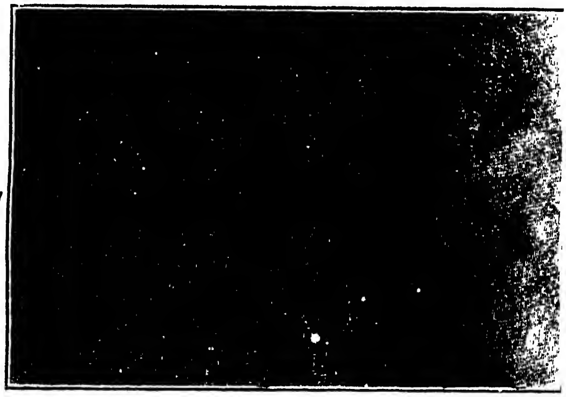


46. THE MILKY WAY ABOUT β CASSIOPEIÆ
(From a photograph by Dr. Max Wolf, from "Knowledge")

for one or more of the rings which Saturn shed in cooling did not coalesce into a spherical satellite, but remained as the wonderful arrangement called Saturn's Rings, which consist of a swarm of tiny meteorites or cosmic dust. Jupiter, the largest of the planets, was next formed. The next ring thrown off by the original nebula behaved like the rings shed by Saturn, and gave birth to the swarm of minor planets. Mars, Earth, Venus, and Mercury, were next born in the same order.

The vast luminous orb which we call the sun, and which we have seen to be still in an intensely hot gaseous condition, is merely the shrunk and dwindled remainder of this vast original nebula. This is a brief sketch of what is known as the Nebular Theory of planetary evolution.

The Beginning and End. It is highly probable that the gaseous nebulæ which exist in great numbers in the heavens are all in an early stage of such evolution, and that all the stars which bedeck the sky are the product of earlier nebulæ, and are surrounded by planets like the sun. But we are now approaching a region which borders on the realms of imagination rather than research. The span of our lives is so tiny in comparison with the vast ages that must go to the growth of even an inconsiderable system like our own, that man has as yet had no opportunity for verifying such a hypothesis. It may well be that the vast drama of stellar evolution passes through an unending and recurrent cycle. We can mathematically foresee the time when the inexorable operation of physical laws will bring back planet after planet to crash into the sun, and the result of such a series of collisions should be to reproduce the fiery nebula stretching far out beyond our own orbit. It cannot, indeed, be as vast as the nebula from which we were born, since the whole system is constantly losing energy in the form of light and heat radiated into space, from which (so far as we know) it never returns. From such a nebula there would be produced a new system with a smaller sun and fewer planets, again in the vast lapse of time to clash together, and to be expanded into yet another new nebula, still smaller and less potent.



47. THE MILKY WAY NEAR θ OPHUICHI
(From a photograph by Prof. E. E. Barnard, from "Knowledge")

A Cosmic Eternity. Thus we can dimly foresee the cosmic future as a kind of switchback, ever making smaller and smaller rushes up opposing hills, till ultimately the machine is brought to rest and the whole mass of material which now composes the solar system voyages through space in the form of one dark, solid, and lifeless globe. Possibly, two such globes may dash together after millions of æons, and again break up into one vast nebula, instinct with that energy which contains the possibilities of living worlds. All this is pure speculation, and yet (as far as we know) it is the only course which the history of our system can take. That history is probably typical of what is going on throughout the universe. Everywhere there is a vast recurrent cycle in operation. The energy derived from some unimaginable cataclysm, converted into heat and light, and gravitational forces, gives birth to a nebula, which in turn evolves a solar system, and perhaps produces some race of sentient beings such as man, as a casual and temporary accident in this evolution. We are, not unnaturally, apt to exaggerate the importance of this detail, but one of the advantages of even such a hasty survey of astronomical history as has been taken here is that it teaches us to estimate the place of man in the universe with a somewhat truer sense of proportion.

THE BEST BOOKS ON ASTRONOMY

"The Story of the Heavens" (Cassell. 10s. 6d.), "Primer of Astronomy" (Cambridge Publishing Co. 1s. 6d.), and other books by Sir Robert Ball.

"Popular History of Astronomy During the Nineteenth Century" (Black. 15s.), "The System of the Stars" (Black. 20s.), "Problems in Astrophysics" (Black. 20s.), "Concise Knowledge Astronomy" (Hutchinson. 5s.), by Agnes M. Clerke.

"Elementary Astronomy," "Manual of Astronomy," and "General Astronomy" (Ginn. 7s. 6d., 10s. 6d., and 12s. 6d. respectively), "The Sun" (Kegan Paul. 5s.), by C. A. Young.

"Myths and Marvels of Astronomy" (Longmans. 3s. 6d.), "Saturn and its System" (Chatto. 6s.), and many other books by R. A. Proctor.

"Astronomy Without a Telescope," by E. W. Maunder (Thacker. 5s.). "Celestial Objects for Common Telescopes," by J. W. Webb (Longmans. 12s. 6d.). "Astronomy with an Opera-glass," by Garrett P. Serviss (Appleton. 6s.).

"Popular Astronomy" (Macmillan. 18s.), "The Start" (Murray. 6s.), by Professor S. Newcomb.

"Handbook of Descriptive Astronomy," by G. F. Chambers (3 vols. Clarendon Press. £2 16s.).

"The Visible Universe" (Lockwood), "Studies in Astronomy" (Chatto. 6s.), by J. E. Gore.

"Meteoritic Hypothesis" (Macmillan. 11s.). "The Sun's Place in Nature" (Macmillan. 12s.). "Recent and Coming Eclipses" (Macmillan. 12s.), "Spectrum Analysis" (Kegan Paul. 5s.), by Sir J. N. Lockyer.

"The Moon," by W. H. Pickering (Murray. £2 2s.). "The Planet Earth," by R. A. Gregory (Macmillan. 2s.), "Jupiter and His System," by Ellen M. Clerke (Stanford. 1s.). "Remarkable Comets," by W. T. Lynn (Bagster. 6d.), and several other books.

ASTRONOMY *concluded*

A SHORT DICTIONARY OF ASTRONOMICAL TERMS

AEROLITE—A meteor which falls to the earth's surface.
Albireo—A double star in Cygnus.
Alcor—Star in Ursa Major.
Aldebaran—Brightest star in Taurus.
Algol—A variable star in Perseus.
Alphard—Brightest star in Hydra.
Altair—Brightest star in Aquila.
Altazimuth—Simplest telescope stand.
Altitude—Height of heavenly body from horizon in angular measurement.
Andromeda—A northern constellation.
Annular Eclipse—When eclipsed sun appears as a ring of light.
Ansa—The space between the ring and globe of Saturn.
Antares—Brightest star in Scorpio.
Aperture—Breadth of a telescope's object-glass, or principal mirror.
Aphelion—A planet's furthest distance from the sun.
Apogee—A planet's furthest distance from the earth.
Arc—A portion of a circumference.
Arcturus—Brightest star in Boötes.
Argo—A southern constellation.
Asteroid—See *planetoid*.
Auriga—A northern constellation.
Axis—The imaginary line on which a heavenly body rotates.
Azimuth—Angular distance of a heavenly body measured horizontally.

BELLATRIX—A star in Orion.
Betelgeuse—A variable star in Orion.
Bode's Law—An empirical arrangement of the planetary distances.
Bolide—A species of shooting star.
Boötes—A northern constellation.

CANIS MAJOR AND MINOR—Two southern constellations.
Canopus—Brightest star in Argo.
Capella—Brightest star in Auriga.
Cassiopeia—A northern constellation.
Castor—A bright binary star in Gemini.
Cepheus—A northern constellation.
Charles's Wain—Portion of Ursa Major.
Colure—Imaginary circle of the celestial sphere.
Comes (Comeez)—The small companion in a double star.
Comets—Gaseous bodies moving through the solar system.
Conjunction—Two or more heavenly bodies apparently near one another.
Constellation—An artificial grouping of stars by map-makers.
Co-ordinate—Elements which determine the position of a body.
Cor Caroli—Brightest star in Canes Venatici.
Corona—The sun's atmosphere.
Culmination—The meridian passage of a body.
Cusps—The extremities of a crescent, as the moon.
Cygnus—A northern constellation.

DEGREE (°)—A celestial measure, the 360th part of a circle.
Demos—One of the satellites of Mars.
Deneb—The brightest star in Cygnus.
Digit—The twelfth part of the sun or moon's diameter.
Draco—A northern constellation.

EARTHSHINE—Faint glow on unillumined part of crescent moon.
Eccentricity—The distance of a focus from the centre of an ellipse.
Eclipse—Obscuration of one heavenly body by another, or by its shadow.
Ecliptic—Sun's apparent annual path.
Egress—The passing of one body off the disc of another.
Ellipse—Shape of a planetary orbit.
Elongation—The angular distance of Mercury or Venus from the sun.
Emersion—The reappearance of a body after eclipse or occultation.
Enceladus—One of Saturn's satellites.
Epoch—Time to which calculations regarding heavenly bodies are referred.
Equation of Time—The difference between true and mean solar time.
Equator—Imaginary line running round the celestial sphere midway between the Poles.
Equinoxes—Those portions of the year when day and night are equal.
Eros—A minor planet between the earth and Mars.

FACULÆ—Bright markings on the solar disc.
Finder—Small telescope attached to larger to facilitate object finding.
Fomalhaut—The brightest star in the constellation Piscis Australis.
Fraunhofer Lines—Dark lines in the spectrum discovered by Fraunhofer.

GALAXY—The Milky Way.
Gegenschein—A luminous appearance resembling the zodiacal light.
Gibbous—A phase nearly approaching "full."
Gravity—Mutual attraction of bodies.
Gyroscope—An instrument for demonstrating the earth's rotation.

HELIACAL—Rising same time as the sun.
Heliometer—An instrument for measuring small angular distances.
Heliostat—Instrument for counteracting apparent motion of the sun.
Hercules—A northern constellation.
Hour Angle—Distance of heavenly body from meridian in hours, etc.
Hyperbola—Form of cometary orbit.

IAPETUS—One of Saturn's satellites.
Immersion—Disappearance of an object during eclipse or occultation.
Inclination—The angle made by an orbit to the ecliptic.
Inferior Conjunction—When an inferior planet approaches nearest to the sun on earth's side.
Inferior Planets—Mercury and Venus.
Ingress—The beginning of transit of one heavenly body across another.

JUNO—A minor planet.
Jupiter—The largest planet of the solar system.

KEPLER'S LAWS—The laws of planetary motions, enunciated by Kepler.

LATITUDE—The angular distance of a body from the ecliptic.
Leonids—Annual shower of shooting stars occurring about November 14.
Libration—An apparent oscillation of the moon.
Limb—Apparent edge of a heavenly body.
Longitude—Angular distance of a body from the first point of Aries.
Lyra—A northern constellation.

MAGELLANIC CLOUDS—Two nebulous objects in south hemisphere.
Markab—Brightest star in Pegasus.
Mars—Planet between the earth and Jupiter.
Mercury—The innermost planet of the solar system.
Meridian—A line drawn through the heavens from north to south.
Meteor—A shooting star.
Micrometer—An instrument for making celestial measurements.
Milky Way—A belt of minute stars spanning the heavens.
Mira—A variable star in Cetus.
Mizar—A star in Ursa Major.
Motion Direct—Advancing in the order of the zodiacal signs.
Motion Retrograde—Advancing contrary to order of zodiacal signs.

NADIR—The point opposite the zenith.
Nebula—A gaseous mass in the heavens.
Neptune—The outermost planet of the solar system.
Nodes—Points where an orbit crosses the ecliptic.
Nutation—An oscillation of the earth's axis.

OCCULTATION—The hiding of a star or planet by the moon.
Opposition—When a planet crosses the meridian at midnight.
Orion—A well-known constellation.

PALLAS—A minor planet.
Parabola—Form of cometary orbit.
Parallax—An apparent shift in the place of an object.
Penumbra—The dull edge of a shadow.
Pegasus—A northern constellation.
Perigee—Nearest the earth.
Perihelion—Nearest the sun.
Perseus—A northern constellation.
Perturbation—The influence of one body on the path of another.
Phobos—A satellite of Mars.
Photosphere—The sun's visible surface.
Planetoid—A minor planet revolving between Mars and Jupiter.
Pleiades—Star group in Taurus.
Pollux—Bright star in Gemini.
Præsepe—Star group in Cancer.
Precession—A slight retrograde motion of the equinoxes.
Procyon—Bright star in Canis Minor.
Prominences—Outbursts of incandescent vapour seen at the solar limb.

REGULUS—Brightest star in Leo.
Refractor—A telescope with an object-glass.
Reflector—A telescope with a mirror in lieu of object-glass.
Rigel—Bright star in Orion.
Rill—A cleft on the moon's surface.
Rotation—Period an object takes to turn on its axis.

SATELLITE—Attendant body; a moon.
Saturn—A planet between Jupiter and Uranus.
Selenography—The study of the moon's surface.
Sickle—The front portion of Leo.
Sirius—The brightest star in the sky, in Canis Major.
Solstices—Points where the sun is northernmost or southernmost.
Southern Cross—A brilliant star group near the South Pole.
Southing—Crossing the meridian.
Spectroscope—Instrument for analysing light.
Spectrum—Analysed light.
Spica—Brightest star in Virgo.
Sun—The centre of the solar system.
Superior Conjunction—When a body approaches nearest to the sun on opposite side from the earth.
Superior Planet—A planet remoter from the sun than the earth.
Synodic—The time which a planet takes to return to the same position with respect to the sun and earth.

TELESCOPE—An instrument for bringing distant objects apparently nearer.
Terminator—The line separating day and night on the moon or a planet.
Titan—Saturn's largest moon.
Transit—Passage of a body across the meridian or a larger body.

UMBRA—Earth's shadow in a lunar eclipse; centre of a sun-spot.
Uranus—A planet of the solar system between Saturn and Neptune.
Ursa Major—A northern constellation.

VARIABLE STARS—Stars whose light varies in intensity.
Vega—Bright star in Lyra.
Venus—Planet between Mercury and the earth.
Vesta—One of the minor planets.

ZENITH—The point exactly overhead.
Zodiac—That portion of the sky through which the sun and other bodies of the solar system move. The Signs of the Zodiac (not identical with the constellations of the same name) are:—Aries, Taurus, Gemini, Cancer, Leo, Virgo, Libra, Scorpio, Sagittarius, Capricornus, Aquarius, Pisces.

continued from page 6626

STRINGED & WIND INSTRUMENTS

The Making of a Violin and other Stringed Instruments. The Pianoforte: Case, Soundboard and Strings. How an Organ is Built

By J. P. LORD

STRINGED INSTRUMENTS

The making of stringed instruments can best be learnt by studying the process of manufacture of the violin; firstly, because the violin is the only instrument which is generally the work of one man only (we speak of real violins, and not of the disgraceful articles which are turned out in factories by the hundred); and secondly, because the four most important stringed instruments—the violin, viola, violoncello, and double-bass—are all made in the same manner. The making of guitars and mandolines will be a simple matter to one who has mastered the method of building a violin, so with few alterations the one description will serve to give an insight into this branch of the trade. Moreover, we might point out that violin-making on a high-class scale is very frequently undertaken by amateurs, many of whom rank with the best of our English makers.

Selection of the Wood. If the selection of wood for the fashioning of a wind instrument is important, for the making of a violin it is doubly so. The wood of the violin makes or mars the tone. Fashion your instrument how you may, let it be the most scrupulously exact copy of a Strad, and if the wood is bad you will never get a good tone. Now, the essential in wood for violin making is that it should of itself possess a musical tone. If you hold up a piece of wood and rap it smartly with the fingers, it gives out a note, of a kind. If it is to be used for violin-making—and these remarks apply also to all other instruments of this class—the note must be a distinctly musical one, clear and ringing, although not necessarily powerful. Anything like a "woolly" sound indicates faulty wood.

The woods generally used are pine, sycamore, maple, and pear, the first being almost universally employed for the top plate or belly of the instrument, and one of the other three for the back.

The wood should be old, well seasoned, and free from all artificial seasoning agents. The beginner had better purchase from a dealer of repute, lest he waste his time making a worthless instrument.

As a further test of the musical quality of the wood, one corner of the slab may be gripped in a vice and the edge played on with a well resined bow, when a distinctly musical tone should be forthcoming.

How to Test Wood. The soundness and freedom from resin of a sonorous wood may be shown by the manner in which it burns. If it flames up rapidly, spurting out jets of fire, it is not properly seasoned, and contains resin: but if it burns clearly and smoothly and evenly, leaving a consistent ash, then it is sound and well dried.

For the back a handsome figured wood adds to the appearance of the violin, but not necessarily to its tone, and tone should never be sacrificed to beauty. As a word of warning to the beginner, we may add that wood with curly markings is difficult to work, and should only be used by experienced hands.

Violin wood comes into the market in two forms, known as "cut on the quarter" and "cut on the slab." Wood cut on the quarter is divided in wedges from the centre of the log to the bark; wood cut on the slab is sawn parallel with the diameter of the trunk.

The Age of the Wood. Much is said about wood being 250 years old, but in the opinion of competent makers great age is not necessary: if the wood is only well seasoned and matured, it will make as good a violin as wood which has lain in store for a century. Wood, however, should be cut from a well grown tree in its prime, before old age has begun to cause the cells to decay, and should be stored for at least seven years before being used for violin-making.

Wood for the belly of a violin should always be cut on the quarter, but for the back it does not matter whether it be on the quarter or on the slab. The belly is almost invariably made in two pieces, the portions joined being those nearest the bark of the two slabs cut on the quarter, because the wood there is stronger than that in the centre of the tree, and the centre line of the belly has to bear the greatest strain from the bridge. The back is made indiscriminately from one or two pieces.

Having carefully selected your wood, if it is in one piece and cut on the slab or quarter, you can at once cramp it to the bench, ready for outlining. If it be in two pieces cut on the quarter, you must first of all shoot the thick edges perfectly true and place them together, so that when the wood is lying with its flat surface on a true level there may be no gap at all between the thick edges, but the two pieces will lie together and form a ridge like the roof of a low-pitched house. When in this position and held up to the light, no ray should be seen between them. With some of the very purest and finest white glue these two edges are now joined firmly together and cramped in position till they are well set. Both pieces, now joined, are henceforth treated as one slab of wood, whether for making back or belly.

Having cramped your wood to your bench, you next plane the ridge, if of joined wood, sufficiently to enable you to rest the wood on when you turn it over, as you now do to plane the flat side perfectly level. In doing all planing, you will have to watch the wood very carefully, so as not to tear pieces out of it.

Drawing the Outline. When this surface is quite level, you proceed to draw your outline upon it, using a templet of veneer or stiff card, made exactly to represent one half of the outline of the violin you propose to make. This templet you must make yourself from any good pattern of violin, or you can construct one by means of compasses and ruler by following the method here given, which was originally devised by Wettengel, a German writer on violin construction, which has since been frequently followed by first-class makers.

On a large piece of paper, or thin wood, draw a perpendicular line down the centre of the exact length of the body, which is generally in the neighbourhood of $14\frac{1}{4}$ in. to $14\frac{1}{2}$ in. Divide this into 72 equal parts [see DRAWING, page 472]. Intersect this perpendicular line by twenty horizontal lines, exactly at right-angles to the centre line, at the points marked as follows, naming the lines as below [see also page 4623].

Line A	at point	8		Line L	at point	33
„ B	„ „	14		„ M	„ „	34
„ C	„ „	16		„ N	„ „	37
„ D	„ „	20		„ O	„ „	39
„ E	„ „	$21\frac{1}{4}$		„ P	„ „	40
„ F	„ „	22		„ Q	„ „	$44\frac{1}{4}$
„ G	„ „	23		„ R	„ „	48
„ H	„ „	27		„ S	„ „	55
„ I	„ „	28		„ T	„ „	56
„ K	„ „	31		„ V	„ „	65

Take your compasses and open them to an extent equal to 9 parts of the perpendicular, and from point *b* describe an arc *aa* on each side of the centre line, *b* being the top end of the perpendicular. With point 24 as centre, and radius *xr* to *b* draw curve *aba*, meeting *aa* at those two points [1]. Mark off points 2 parts distant from perpendicular, and on each side of it, on line C; call these *cc*. With centre *cx* and distance *ca* draw curves *ad* on each side, meeting line A at *d* and *d*. On B mark two points, *e*, *e*, one part distant on each side of centre line. With these as centres, and *ed* as distance, draw curves *df*, meeting line D at *f*. This practically finishes the upper portion of the violin body.

For the middle, or narrow portion, start by setting off on L two points *gg* $11\frac{1}{3}$ parts distant on each side of perpendicular, and then eleven points further distant from *g* mark two more points *hh*, and with *h* as centre and *hg* distance draw curve *gi*, meeting L and P at *g* and *i* respectively.

On line K set off $23\frac{3}{4}$ parts from perpendicular, on each side, to *kk*, and with *k* as centre and distance from there to point where curve *gi* cuts line M as distance, describe curve from that point to 1, meeting line H at 1. This gives the main curves of middle of body. Where there are tiny angularities between curves, they must be worked down by hand to a flowing sweep.

The lower part of the curves of the lower portion are obtained in this way: Take lower point of centre line, and call it *rr*. Open compasses *qq* parts, and with *rr* as centre describe arc *vv* on each side of middle line. With 35 as centre, and 35 to *rr* as distance, describe curve *v*, *rr*, *v*, cutting first arc at *v* and *v*. On line S mark two points *xx* 6 parts distant from centre line. With *x* as centre, and *xv* as distance, draw curves *vy*, meeting line V at *y*.

Set off two points at T, 4 parts distant from *rrb*. Call them *zz*, and with *z* as centre, and *zy* as radius draw curve *y*, *aa*, meeting R at *aa*. This completes the main curves of the lower body.

The Corners. For the upper corners, set off $24\frac{1}{2}$ parts on line G from perpendicular to *oo* on each side, and with *o* as centre, and *of* as distance, draw curve *fp*, meeting E at *p*. On line I set off two points *mm* on each side of *rr*, *b*, and distant from it $14\frac{2}{3}$ parts. With *m* as centre and distance to *l*, draw curve *ls*, above H. On line E set off 22 parts, giving *q*, and with *q* as centre and distance *qp* draw curve *ps*, determining point *s*. With 20 as centre, and $16\frac{1}{3}$ parts as radius, describe a short arc cutting *ps*, *ls* at *s*, giving two angles of corner.

For the lower corners, set off 24 parts on line O, from perpendicular to *bb*, and placing compasses on this point, open them to *cc* and draw curve *ccdd*. On line N set off $18\frac{1}{2}$ parts, from perpendicular to *t*, and with *t* as centre and *ti* as distance, draw curve *iu*, determining point *dd* of corner, as in the upper corners. With compasses on point 49, and distance equal to $19\frac{3}{4}$ parts, draw arc meeting *iudd*, and *aadd* at *dd*, giving angles of corner. The entire pattern is thus completed.

The corner, as indicated, will have to be rounded off, and the points at the angles of the corners neatly joined. To obtain the proper rise for the height of the back and belly, take a piece of hard wood and mark a point half way along it, and one quarter from its further edge. The wood must be slightly longer than the centre line of the body. With a piece of string, or very large compasses, with a radius equal to 216 parts of former scale, describe an arc meeting line perpendicular to edge of wood through A at A. This will give the curve of the rise, and if sawn out neatly will give a useful trying plate.

Of course, this pattern is not to be taken as a sample of the best man can devise—each maker constructs, to a great extent, his own pattern—but it will serve as a general guide for the beginner to work upon.

Having laid your templet, or pattern, flat on the planed side of the wood, mark carefully all round it with a pencil, and afterwards touch up your plan by hand. If your templet is a half one, having drawn one side, you must reverse the pattern and complete the other.

Cutting out the Pattern. That done, take a bow saw, or coarse fret saw, and cut out the marked pattern, keeping well outside the marking, lest a slip should ruin your work. Having done this, a very flat knife, especially made for violin-makers, is taken, and the wood pared down exactly to the outline.

Having got your outline right, with a gouge reduce the edges on the outer, or convex, side of the plank to about $\frac{3}{16}$ in. in thickness. That done, the wood must be further reduced by filing and rasping, or by gouging and planing, till it is about the right thickness at centre and edges, when measured with your pattern cut out of wood, keeping your work as smooth and even as possible.

Remember the shape of the outline of a violin and its general figure is its pattern; its model is the curvature of its back and belly. The body is divided roughly into three—the upper third to the upper corners is called the Upper Bout, from there to the lower corners is the Middle Bout, and thence to the tailpiece is the Lower Bout.

The reduction being right, and even all round, at this stage some makers advocate inserting the purfling, those strips of black-and-white wood which form the ornamental border round violins. This plan has much to recommend it, because if a slip be made it is not so injurious at this point as it would be later; while if the entire back be ruined, surely it is better to spoil an unfinished back than one on which you have spent days of labour.

A purfling tool is an arrangement for marking two or more fine lines at a regular distance from the edge of an object. This instrument is run round the edge, and when the lines are clearly scratched in, they must be deepened with a knife, and then the wood between removed with a fine, sharp gouge. The purfling instrument will mark a space of about an inch, where the button

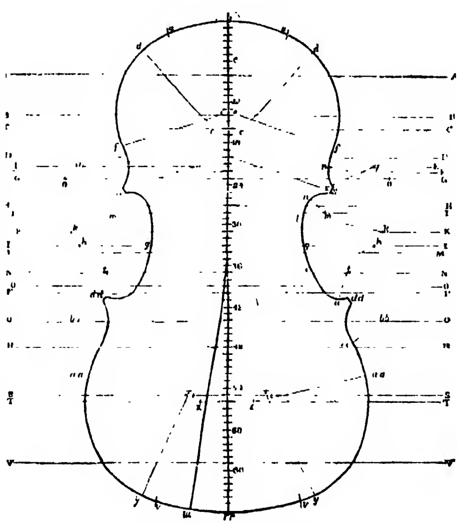
of the violin comes at the top of the upper bout, and this piece must be traced by hand.

When the groove has been cut out, the purfling, which consists of fine strips of black-and-white veneer, must be cut to approximate lengths, and then bent by passing it over a purfling iron—a hollow tube, heated by means of an iron which goes inside it.

The purfling must be gently handled, and passed over and round the iron till it assumes the proper curve, more by coaxing than by force. It is then ready for insertion. With a flat stick, or with the blade of an old knife, very hot glue is laid along in the grooves, and then the purfling gently forced into its place, some ingenuity being used to make the pieces join neatly, especially at the corners, where they should meet at an acute angle. The purfling being in its place, a little very hot glue is run in all round it to make all secure, and then the back is put away to dry.

While the back is drying the belly, or body of the instrument, can be got on with, its outline being traced and cut out exactly like the back. If you wish, you can also reduce it on the upper face at this stage, and purfle it, thus avoiding the use of much hot glue when you are nearly ready to polish it later on.

Cutting the Groove. When the purfling is dry, if it has been done, or when the outline is clear, if the purfling is postponed, the next thing to do is to cut a groove to the depth of an inch, and about $\frac{3}{4}$ in. broad, all round the back or belly, the edge of it being about $\frac{1}{32}$ in. from the inside edge of the purfling. This is best cut purely on the curve, avoiding the corners at first, and afterwards finishing them up with a gouge. Down to this groove the model is worked, using either plane or sandpaper folded over a cork rubber. Opinions differ as to the advisability of employing sandpaper, its opponents saying that it damages the fibre of the wood and injures the tone, while advocates of its use declare that planing is worse. The beginner will find sandpaper easier to work with, because it does its work more gradually, and there is less risk of catching on a fibre and ripping up a valuable piece of wood.



1. THE VIOLIN PATTERN

Finishing the Back. Working, then, with sandpaper or plane, the curvature of the back must be brought to fit exactly the model made, and the whole back must be finished off smooth. Between courses of papering or planing it will be found necessary to damp the wood, for that makes the soft parts swell up above the level, and proves that what appeared a perfectly level surface would have become rough on varnishing. The raised portions can easily be removed with paper or tool, and a perfectly smooth surface which will last thus produced.

The outsides of the back and belly being finished, and the model made correctly to pattern, the inside of the two tables, as they are called, are hollowed out.

Hollowing Out the Frame. The table is laid on a hollowed bed, protected by paper so as not to injure the smoothed surface of the outside, and on the inside is drawn the curved outline, which is like a guitar, the corners being only indicated by broad curves. This is drawn at a distance from the edge sufficient to leave a good flat rim for the ribs, or sides, to be eventually glued to.

A shallow cut is made along this line, and from that as a starting point the hollowing is worked. To graduate the hollowing nicely three grooves are cut across the inner side of the table of such a depth that the middle groove callipers a good $\frac{3}{16}$ in. in thickness of wood, the upper and lower callipering $\frac{1}{8}$ in. These fall away very little towards the edges at the outset. These grooves are best cut at the three nodal points, which correspond roughly to points 16, 37, and 55 on our centre line. From these the back can be hollowed all over gradually, the callipers being frequently employed to gauge the thickness all over, the taper being made very even and regular. Then with sandpaper, or spokeshaves, the reduction must be gradually carried on till the table varies from $\frac{5}{32}$ in. at the centre to between $\frac{1}{12}$ in. and $\frac{1}{16}$ in. at the edges. These measurements have been found to give an excellent tone for the back. The belly requires to be made only $\frac{1}{8}$ in. in thickness at the centre node, or breast, and to be reduced from that to a $\frac{1}{16}$ in. The reduction varies a little according to the resonance of the wood, very "active" pine requiring less to be taken off than would a

The Sound Holes. When the belly has been properly thinned down the time has arrived for cutting the four sound holes. These are of various patterns, some distinctive of certain schools of makers. Select good pattern, suitable for your violin, and trace it on the wood, or stencil it if you prefer to do so. Then, with a fine fret saw, cut it out, keeping well inside the line, finishing afterwards with a sharp knife. The F should lie on the belly from point $32\frac{1}{4}$ to point $46\frac{1}{4}$, and the centre of the upper round holes should be opposite point 31, and that of the lower opposite point $44\frac{1}{2}$. The outer notches fall opposite point $39\frac{1}{4}$.

The Bass Bar. The bass bar is a strip of wood glued to the inside of the belly under the G string of the violin. In length it should be 36 parts long, one part and one fifth in breadth, and 2 parts thick in the centre, sloping down to two-thirds of a part at the ends. Perhaps the best position for it is parallel to the centre line. It is one-third of a part from the upper round of the left F hole, and has its centre opposite 40.

The centre line of the belly may require strengthening, and if this is so small squares of veneer may be glued along it, the grain of the veneer running across the grain of the belly diagonally.

The Ribs. The ribs or sides are formed of strips of wood carefully bent by heat, in much the same manner as the purfling was done, till they assume the exact shape of the various sections of the outline. The pieces are six in number, corresponding to the right and left sides of the three bouts. In thickness they should be about $\frac{1}{16}$ in. and in depth they vary according to the proportions of the outline. The main point to be borne in mind is that the "box" of the body should contain a mass of air which when set in vibration will give a fixed note, and violin makers generally select C with 512 vibrations per second as their standard. A fairly general depth is $1\frac{1}{4}$ in. at the broad end and $1\frac{1}{8}$ in. at the narrow end of the violin, which corresponds to a body $14\frac{3}{8}$ in. long constructed on the plan given.

At the same time as the ribs are prepared the linings, which are thin tapering slips of pine wood, must be cut. There are two linings to each piece of the ribs, glued on the inside of the curve. The corner blocks should also be made ready. These are of such a shape as entirely to fill up the corners, reducing the inside contour of the violin to the guitar shape.

The ribs and linings having been carefully bent to the proper curves, the ribs are cramped in a beechwood mould exactly resembling the outline of half the violin, and when there the corner blocks are glued in, and the linings fastened on, the whole being cramped up to make all firm. When set the edges must be pared absolutely level and all is ready for attachment to the back, on which the end and the bottom blocks have been glued. The ribs are kept in place by a series of cramps, and extend up to the edge of the button, where the neck groove will be cut for the fixing of that portion of the instrument.

When properly dry and set, the groove is gouged out, and the belly glued on. Many makers drive two small pegs through the ends of the belly into the end blocks, just as they are about to cramp up the body.

The Neck. The neck of the instrument should be 26 parts in length, measuring from the body of the instrument to the nut, which is the little raised bar of ebony over which the strings pass on their way for the pegs. The neck and head is cut out of a block of wood, and really is a matter of wood-carving. Examination of the neck of a violin will show the shape to be aimed at better than pages of description. The fingerboard must be firmly attached to the neck by glue, and the neck must be set on the body in such a manner that the end of the fingerboard near the bridge is $\frac{13}{16}$ in. above the wood of the belly. Careful joinery is all that is needed to effect this. The peg for the attachment of the tailpiece is glued into a hole bored in the bottom block, and the tailpiece attached by means of loops of gut.

The Soundpost. The soundpost is the bugbear of beginners. It has to be cut so accurately that every portion of its upper and lower surfaces is in close contact with the wood of the belly and back respectively. It also must be of such a length that it just fits perpendicularly between the two when placed with its edge nearest the neck, just in a line with the back of the foot of the bridge under the E string. It must fit tight enough not to slip when the strings are slack, and yet not so tight as to strain or exert any appreciable pressure on the belly or back. Only patient chipping and scraping will ensure this result being attained. The post is inserted through the F hole nearest to it, and it is adjusted in position by means of a special iron instrument, known as a setter. The diameter of the soundpost and the breadth of each foot of the bridge must coincide with the breadth of the bass bar.

The Bridge. The bridge, which is made of maple or beech, must be set up so that exactly half of its thickness is on each side of a line drawn between the inner notches on the F holes, and passing through 40. The thickness of the upper edge of the bridge must be $\frac{4}{7}$ of a part, and of the soles of its feet $\frac{1}{5}$ of a part. Its extreme height depends on the length of the instrument, and is reckoned at $\frac{18}{103}$ of the body length of violins and violas, and $\frac{65}{452}$ of length of 'cellos and basses.

The soundpost being fitted, it is removed till the instrument is completed. If the purfling has not been done it is now added, and a piece of ebony let in where the tailpiece will rest.

Varnishing. A final polish is given to the violin, and then comes the varnishing. After the final polish has been given to the plain wood it is just run over with a damp sponge and allowed to dry. This throws up a microscopic roughness which holds the varnish well. The selected varnish, at first well diluted, is then applied in successive coats. Each coat must be permitted to dry thoroughly without artificial aid before its successor is applied. Each maker has his own recipe for varnish, and it is impossible to recommend one more than another, always provided that oil varnishes are better than spirit if properly applied, and have a more lasting effect.

The final varnishing and rubbing with the palm of the hand being completed, the pegs can be put in, the soundpost readjusted, the tailpiece looped on, and the strings attached. The senseless wood has become an instrument—whether musical or not depends upon the care which has been expended upon it.

The above instructions apply to the making of all instruments of the violin class, provided that the ribs of 'cellos and basses are made double as deep in proportion as those of violins and violas. This is done to obtain the proper volume of air inside the box, because the length of the body, if the ribs were of the former proportions, would be too long to be wieldy, so defective area in the base of the box has to be compensated for by increased height. For comparison we give these proportions for ribs:

Violin and viola, $6\frac{1}{4}$ parts at tail, tapering to 6 parts at neck.

'Cello and bass, 12 parts at tail, tapering to $11\frac{1}{4}$ parts at neck.

Miscellaneous Stringed Instruments. The making of guitars and mandolines is rarely undertaken in this country. Should, however, our readers wish to make either, the foregoing directions for violin-making will be of assistance. The wood of the belly of guitar or mandoline should be the best violin pine, old, and free from flaws, and should of itself be musical. It will not have to be hollowed out. A bass-bar may be placed under the lowest string, but a soundpost is not generally employed, though its use is commendable. The back of a guitar may be slightly hollowed, and with a model resembling rather a flat violin. The back of a mandoline is usually built up on a wooden frame, of strips of wood glued together. Harp-making is a "close trade," being in the hands of a few families who have made a speciality of this beautiful, but unfortunately almost forgotten, instrument.

Repairs. It is generally said that he who made can mend, but in the case of high-class stringed instruments this is not so. Strange as it may appear, the calling of a repairer of stringed instruments ranks higher than that of manufacturer of the same. The reason is not far to seek. The maker knows the exact proportions of the pattern he is engaged upon, has all the calculations before him, and, given good technical ability, produces a very even series of instruments. The repairer, on the other hand, has instruments of every conceivable pattern and model passing through his hands. He knows nothing about the defective instrument when it is sent to him, but he has to discover its normal and theoretical qualities for himself before endeavouring to restore the lost tone. He has to be scientist, artist, and craftsman in one.

Naturally the commonest form of repair to be executed is the mending of a crack. This is generally to be effected by careful gluing with clean glue, the liquid being worked into the crack by a very gentle bending backwards and forwards of the part which is cracked. Usually it is necessary to open the instrument to do this. The belly is easily removed with a flat-bladed knife, if great care is exercised and no undue forcing attempted. Worm-eaten pieces and badly smashed portions have often to be excised entirely, and a fresh bit of wood, matching the original as nearly as possible, inserted. Glued portions are separated by overlaying them for a time with wads of linen soaked in lukewarm water. Warped backs or bellies are brought into line again by damping, steaming, and drying in specially-cut cramps. The actual work is that of the most expert cabinet-maker and inlayer: the knowledge of what is to be done is only acquired by great experience, and a natural gift for the occupation must be present.

THE PIANOFORTE

One thing is bound to strike everyone who first makes an acquaintance with the manufacture of pianos—namely, the extraordinarily small amount of skilled labour requisite for their production. True, when once the piano has been put together, the greatest skill and the utmost refinement are necessary for the proper regulation and tuning of the finished instrument: but, prior to that stage being reached, only at one or two points in its progress does the piano in the making call for the exercise of great skill and experience. We speak of the daily work in the factory: the designing and calculating of improvements is quite another matter, and calls forth the powers of the engineer, musician, and draughtsman.

For purposes of convenience, let us divide the piano itself into three distinct parts. First there is the case, then we have the soundboard, with its frame and strings attached to it, and lastly we have the action, or mechanism, which transmits the blow from the finger to the string.

Making the Case. Case-making is a branch of high-class cabinet-making pure and simple. Certainly, the maker has to understand the conditions to which the cases are to be exposed, but for all that it is really a branch of carpentry. As such, we need not discuss it here, save to say it is essential that the wood be seasoned to perfection, and that the curved sides of grand pianos are formed of a great number of strips of thin wood, bent and glued together, huge moulds and cramps being employed in the process. A close study of the articles on CARPENTRY and CABINET-MAKING [page 6579] will put the student on the right road to learning his calling.

The case being made, it has to be polished, and again, the section on FRENCH POLISHING [page 6591] will give all needful instruction. We have, therefore, two main processes to study here, the first dealing with the material from which the sound is produced, and the other with the means by which that sound is evolved.

The Sound Mechanism. We will now take the portion of a piano devoted to the making of the sound. First there is the back, which must be strong, to support all the material which lies on it, or which is attached to it. At the same time it must be of such a form as not to spoil the resonance in any way, for on it lies the soundboard, which forms the second division of this part of the piano. On the soundboard in modern pianos we find the iron frame, which takes up the strain of the strings, over which we have the strings, attached to pegs, passing over certain bridges and between small pins. There we have the entire sound-making portion of our instrument.

The back, or underside, in a grand piano is built of well-seasoned wood, sometimes of best English oak, and occasionally, in cheaper instruments, of beech. It consists of a stout framework, carefully mortised together, with bars across at different points. In English upright pianos these bars are usually vertical, and seven in number; in German pianos the bars run diagonally, as they do in most grand pianos. The oblique bars are said to give a smoother singing tone to the instrument, but they are not conducive to great durability. The making of these bars is, it will be admitted, merely carpentry. The calculation of their thicknesses, and the selection of their positions with a view to the quality of sound desired, is the work of a practical and theoretical acoustician. To this back, or underside, is attached the soundboard.

The soundboard is constructed of lengths of the finest spruce fir, similar to that of which the bellies of violins are made. These lengths are glued together with the greatest care, just as the belly of the violin is joined, and the direction of the wood is so arranged that, where possible, the entire length of both the bridges over which the strings pass shall lie on a single plank. The selection of the wood for the soundboard is a matter of much judgment, for on its resonance depends the greater part of the tone of the piano. Need we say that the wood, like that of the violin, must have a tone of its own?

A moment's thought will show us that the strings must exert an enormous downward pressure on the bridges, and therefore we must fasten the belly-bars across the underside of the soundboard to resist this pressure. The grain of these bars must run in an opposite direction to that of the wood of the soundboard itself. The bars are also necessary from an acoustic as well as a mechanical point of view. Anything like proper vibrations in the soundboard itself would be exceedingly undesirable, and these bars serve to prevent such being established other than by the vibration of the string.

Modelling the Soundboard. The soundboard, when the lengths of pine have been glued together, is the object of the most scrupulous care of, perhaps, the most highly-trained man in the entire piano factory. Remember how we had to give a "model" to the belly of the violin. The soundboard of a good piano has to be modelled just as carefully. It is of a more or less convex shape, the rise being towards the strings, and it tapers gradually away in various directions, the thickness

being suited to the string which will lie over it. No fixed rule can be laid down for this tapering, nor for the thickness of the soundboard at any one part, each maker having his own private formula, preserved as a secret, which gives to his instruments their individuality.

After the soundboard adjuster has done his work, scraping, chiselling, and planing here and there till the wood gives out the right ring when he taps it, and till his callipers tell him his thickness all over is right, it is covered with several layers of varnish to prevent cracking and warping. The varnish used affects the ultimate tone, just like the varnish of the violin-maker, and differs with each firm of makers.

The "Wrest Plank." Above the top of the soundboard in cottage pianos, forming, as it were, a border to it, and at the lowest end of that of grands, separated from it by a small space, is a massive log of hard wood, generally made of layers of beech or oak, the grain of each successive layer running across those of the previous one to prevent splitting. This block is also very frequently further strengthened by a metal plate.

When we mention that the function of this plank is to hold the pegs by means of which the strings are tightened, the necessity for this care becomes evident. It is known as the *wrest plank*, and the pegs are called *wrest pins.*

The Bridges. Across the face of the soundboard are two bridges made of hard wood. It is through these that the vibrations of the strings are transmitted to the soundboard. The distance between them varies with the length of the string. The one furthest from the wrest plank is called the belly bridge, and is made in two parts, that taking the covered bass strings being separated from the bridge for the smaller strings. If the detached portion of the belly bridge is so placed that the bass strings have to lie over certain of the other strings, then the piano is spoken of as "overstrung." The second bridge, or wrest plank bridge, is placed close to the wrest plank, and in grand pianos the wires are pinned down to it, to prevent their being in any way shifted by the impact of the hammer, which in this class beats the string away from the soundboard, but in uprights drives it towards the belly. These bridges are firmly glued and screwed on to the soundboard.

The Iron Frame. Above all this is placed the massive iron frame, which has to withstand the enormous strain of the strings, a strain which, in large concert grands, approaches 30 tons. The iron frame is cast of the best hard metal, carefully finished by mechanics. It is attached to the wrest plank, soundboard, and back. At one end it bears the pins to which the fixed ends of the strings are attached.

Across the iron frame are bars, the direction of which differs in almost every make of piano. These are simply mechanical contrivances for enabling the frame to withstand the pressure upon it. The iron frame is bolted into its place by massive bolts and screws.

Stringing. When the piano has reached this stage it is taken to the stringer, who is often a youth destined later to become a tuner or regulator. He begins to put on the strings, placing the loop over the end pin and the free end through the hole in the wrest pin, which he then hammers into its hole and tightens up slightly.

The strings being all in place, the body of the piano passes to the "chipper up," who is an elementary tuner. This workman, or artist in embryo—for he is in the first stage of skilled work—starts to tighten up the strings into some sort of tune. To get the sound, he chips the strings with a piece of ivory, twanging them like the strings of a mandoline. He does not start at one end ot the piano and work right through, but, "setting" a scale in the centre, tunes roughly from that, as if tuning a proper piano. This prevents the strain from being put on one end suddenly, leaving the other loose, a proceeding which would damage the piano. [For PIANO TUNING, see page 6442].

Stretching the Strings. The instrument having been brought into some resemblance of tune, a piece of board, covered with leather, is taken and pressed with great force up and down the strings to stretch them and, as far as possible, remove all spring in them.

After this operation it will be found that the tune has vanished, and so the piano must be re-tuned, being brought almost up to pitch. It is then left for a few days, and then again tuned to pitch. Four or five such tunings will be necessary before the tune will stand, and only then is the piano ready to be tried with the action. This chipping up is generally done after the back, soundboard, and so forth, have been firmly screwed into the case which is to contain them.

The Action. Very few piano-makers in this country make their own actions; unfortunately, most of them depend on the Continent for the supply of very second-rate mechanism. A few firms, however—not half a dozen, alas!—prefer to manufacture their own, and the result is that their pianos contain sounder and better actions than any made abroad.

The bulk of the action for the best English makes of pianos is cut out of the finest and hardest French hornbeam, a wood with very little grain, and one which works as cleanly as metal. It is little affected by moisture, and consequently actions made of this material rarely stick, provided they have been properly made. Foreign actions, produced in a violent hurry and badly finished, manage to stick, even when made of hornbeam. Beech is used for a few parts, and English oak is used for the action rails running right across the piano, against which various portions rest, or to which portions are screwed.

Of actions there are many, but as examples we will take two typical actions for upright pianos—namely, the over-damper check action and the under-damper check action, with a tape. These are named according as the damper is over or under the hammer. Of actions for grands we shall not treat, because, until the beginner has mastered the fitting and regulating of upright pianos, he will not be entrusted with the more costly action of a grand. We will, however, indicate the principle upon which the grand action works.

The actual making of the component parts of an action is accomplished by machinery, the work being so subdivided that unskilled labour can be employed to an enormous extent. Thus, one operative will do nothing but pass wood into the sawmill; another will be solely engaged in boring holes in one particular part of the action: a third will give the correct bend to the various wires used, and so forth, each operation being performed on machines fixed to an exact gauge, so that error cannot possibly creep in. Only when all the individual parts are ready to be assembled does the skilled man step in.

Where, then, does the superiority of the English action come in? In attention to detail, and in the quality of the accessories which are indispensable

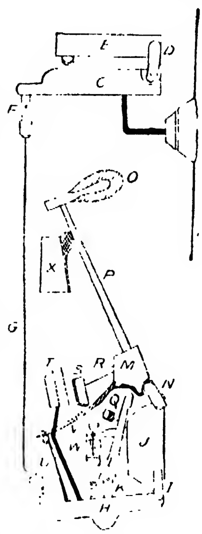
to the proper making of actions. We will indicate one small particular. The holes through which the tiny wires which act as hinges for the moving parts of the action should be lined, or "bushed" with cloth. In Continental actions this is never done so efficiently as in English actions, with the result that, after a time, the mechanism rattles, and rebushing becomes necessary if the piano is to work properly.

Over-damper Actions. The portions of an over-damper check action are best understood by reference to the accompanying diagram [2]. It will be seen that there are in reality two distinct motions, to be accomplished by two sets of levers operated initially by the primary action of the end of the key lever. The first motion is the withdrawal of the damper A from the string B, by the combined actions of the damper lever C, which is hinged on to the damper flange D, and checked in its turn by the damper rail E, to which also the flange is screwed. All flanges and parts screwed to fixed rails are fastened by one screw only, but, to prevent them from shifting, are provided with a groove across them, into which fits a raised bead on the rail. The damper lever is lifted by the damper lifter F, moved by the damper wire G, which passes through the base of the end of the jack rocker H. The wire is free in its hole, and has its button screwed upon it, on which the jack rocker presses to lift it. When the sustaining or loud pedal is pressed, by an arrangement not shown in the diagram, C is lifted, and so the dampers are moved away from the strings. The end of G, being loose in H, enables the jack rocker to move, when the key is struck, without affecting the damper at all. At the knob shown on the lower part of the jack rocker, a rod is fixed, which is pushed up or down by the direct action of the key.

The jack rocker may then be considered as the junction of the two systems of levers. It is hinged by means of the jack rocker flange I to the hammer flange rail J. Almost above the lower protuberance in the diagram is fixed the jack flange K, carrying the jack L, the upper end of which presses on the hammer butt M. The hammer butt is fixed to the hammer flange rail J by the hammer flange N, and on being pushed upwards by the jack, tilts the hammer O, carried by the shank P, against the string B. The little spring under the foot of the jack is to keep that part close against the hammer butt, and the jack is prevented from coming too far forward by the jack check rail Q, seen in section. The felt on this rail is adjustable by means of a screw. R, S, T, U, and V form the check system, and are named respectively the back check shank, the back check, the back catch on which the back check hitches when the hammer is far enough forward, and which regulates the rebound after a stroke—the stirrup wire, and the tape. The tape keeps the hammer from going too far forward, or from sticking close to the string after the key has been raised. W is the escapement rail, with screws and buttons for regulating, and X is the hammer rest, covered with padding against which the hammers lie.

Each of these distinct parts is made separately, and only assembled at the last minute. The curved and shaped pieces of hornbeam are first of all planed to shape with moulding planes, a whole strip some 6 ft. long being dealt with at a time. This is then cut up into sections by means of a revolving saw driven at very high speed. The sunk grooves, where the joints work, are then cut to a regular depth by another machine cutter, the depth being regulated by gauge. After this, the holes for the pins are bored, and then the holes are lined or bushed.

Lining the Holes. The bushing is done in this way. A strip of superfine cloth, known as "Mechanics' Cloth," and costing about 20s. a yard, is prepared of such a width that if forced into the hole its edges will just meet. These strips are cut by machines. The strip is rolled up spill-wise and the point drawn through a hole, and then through a second, and so on, till the strip of cloth is threaded through as many pieces of bored wood as will go upon it easily. Just as the cloth is drawn through the outside is slightly smeared with paste, to hold the bushing in the hole. When the strip is full, the various sections of wood are separated from one another by cutting the cloth with a sharp chisel, and when the edges are trimmed the holes are all neatly bushed. The bushing is then just opened for the pin by means of a needle. The shanks are made by drawing strips of wood through a revolving series of cutters, the strip emerging as a round stick, which is subsequently sawn up into lengths.



2. OVER-DAMPER ACTION
(For explanation, see text)

The base of the hammer butt, where the jack impinges, and the face of the back check are faced with very fine doe skin. This skin is far better than sheep skin, which is commonly used abroad. It must be shaved down to one regulation thickness before being cut into strips for the purpose of being glued into place. It is often advisable to fasten a piece of thick felt or cloth behind corners covered with this leather, as the shock is thereby softened, the action improved, and the life of the leather greatly prolonged. The felt for the hammer head is woven specially to a taper, and only requires bending and gluing into position, being pressed down with heated curved irons.

Fitting the Action into Position. When sufficient sections have been collected to make up an action a fitter builds them into position, by screwing the various flanges on to the rails attached to the action frame, which is made to fit the particular piano to be completed. Then he sees that each individual action works smoothly, and by means of the regulating screws gets all the levers to have about the right amount of play, leaving the final regulating to the expert later on.

In another part of the shop the keys have been sawn out, and the ivory or celluloid attached. Ivory, of course, cannot be bent, but celluloid can be bent by heat, and thus made to cover the top and ends of the keys. The holes for the pins and pivots are bored by machinery and the portions of the keys which play on the rod of the jack rocker burnished with black lead, or covered with felt or leather, according to the method employed by the particular maker. Then the keys have holes bored in them and lead weights inserted, of sufficient size, to nearly balance the entire key at the pivot when in contact with the action and the

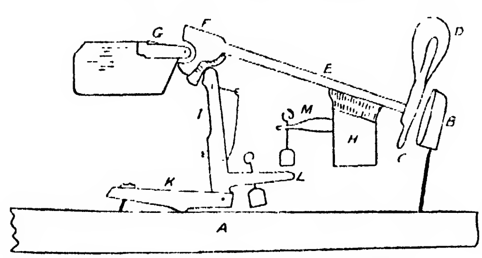
hammers lying back. The damper lever of over-damper pianos is also generally weighted, to ensure the damper falling forward on to the string as required. These weights are cast so as exactly to fit holes bored in the wood for their reception. The fitting must be done very neatly, lest a rattle should be set up.

All these adjustments having been made, and the keys placed on the key bed, and brought to a proper level by means of washers, or punches as they are sometimes called, placed under the keys round the pins, the action can be placed in position in the piano, and the instrument handed over to the regulator. At this stage the rail which is to lift the dampers is connected to the pedal levers which have been fitted inside the case, and the damping felt can be attached to the action, if the soft pedal is to be operated in that manner.

Under-damper Actions. The under-damper action, which we illustrate [3], is very similar to the over damper, save for the actual damping arrangements. The lettering of the hammer and check mechanism will, therefore, remain the same as in the previous illustration. The damper alone will claim our attention, together with the means of operating it.

In this action it will be noticed that the damper is inside the hammer mechanism, and the damper lever, which is in one piece, and marked A, is operated by a portion of the jack rocker on the opposite side of its hinge to the hammer mechanism. Did the end of the jack rocker touch the end of the damper lever, then, when the key was depressed, the end of the rocker would fall away from the lever. This would not work the damper. The damper lever is attached to the hammer flange rail by the damper flange C, and the lever has a small spring bearing against it, just sufficiently hard to press the damper firmly against the spring. The end of the lever, near the rocker, is covered with fine leather, and sticking upright in the end of the rocker, lying close to the end of the lever, is a small metal rod, flattened out into the shape of a spoon. This is marked Y.

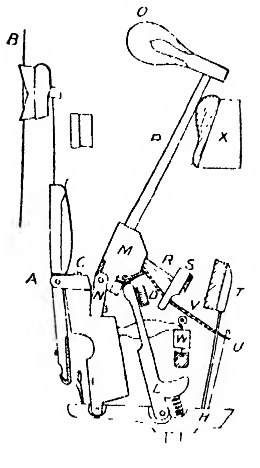
By means of a screw passing through the bottom of the lever the leather facing can be made exactly to graze the smooth surface of the spoon when the hammer is at rest. If, now, the jack



4. SQUARE AND GRAND ACTION
[For explanation, see text]

rocker be lifted by the depressing of a key, the end of the rocker beneath the lever will fall, but in so doing will thrust the spoon a little forward. The forward movement is not very great, but it is sufficient to enable the spoon to press against the leather-faced end of the lever, and so to lift the damper off the strings. On the key being released the spring returns the damper to the string. In this class of action the loud pedal mechanism may be of any kind which will press the entire set of dampers back from the strings a fraction, and may operate either above or below the damper flange.

Actions for Use in the Tropics. There is a new pattern action, which has recently been invented, for fitting to instruments intended for use in hot climates, which is excessively simple, while at the same time it is most efficient. In it the key acts directly on the jack rocker: the jack is very long indeed, and carries two projections on it at an interval of about 1½ in. distant. The lower one operates an over-damper action of the pattern shown in our former diagram. The inner and upper one carries the back catch, which in this case has the felt facing outwards. The hammer butt carries the back check, which is on a wire bent over the back catch, and with the leather facing turned inwards. The top of the jack acts direct on the hammer butt. By this means it will be seen that the friction, and consequent sticking points, are brought to a minimum, and there is much less padding for insects to destroy. The touch of these frictionless pianos is very delicate and they are fast becoming popular. In place of a tape, a small loop is attached to the hammer butt, and this hooks into a curved spring fixed in the upper part of the jack, the spring serving the double purpose of pulling the hammer back, and keeping the jack close up against the butt.



3. UNDER-DAMPER ACTION
[For explanation, see text]

Grand Piano Actions. The actions of grand pianos, as we have already said, are exceedingly complicated, but the principle which underlies their construction can be gathered from our diagram [4], which represents the action of an old square piano. It will be noticed that the key itself carries the back check, and the back catch is a prolongation of the hammer head in a downward direction. The jack rocker rests directly on the key lever, and the escapement lever, with its button and screw, also acts on the key, and, as well, on the set-off button attached to the escapement rail. The damper, which is above the string, may be raised by a wire fixed into the key lever at any point between the rocker and the back check. The parts are these:

A is key lever; B is back check; C is back catch; D is hammer head, and E hammer shank; F is hammer butt; G is hammer flange; H is hammer rail; I is jack, with spring and silk loop passing through jack or round it and attached to hammer butt; K is jack rocker; L is escapement lever and regulating button; and M is escapement rail with regulating button, or set-off button.

Regulating a Piano. The first thing the regulator does on having a piano handed over to him for adjustment, be it old or new, is to see that all the keys are perfectly level. If they are not, he places paper or cloth punchings, or wads on to the centre pin till all are exactly level. This will not,

as a rule, be necessary with a new piano, but it is mentioned because it frequently has to be done to old instruments. If the keys are too loose on the front holes the oval guide pins can be turned a little till they have free play, but are not able to shake. The depth of the touch is then tested. It should be about $\frac{3}{8}$ in. deep in the middle registers and about $\frac{1}{32}$ in. deeper or shallower in the bass and treble respectively. The correct depth can be arrived at by placing cloth or punchings under the middle rail to make the touch deeper, and under the back or front rail to make it shallower.

The Position of the Hammers. The regulator next sees that all the hammers are level and properly spaced, so that they strike the strings fairly. In a new piano, made with an English action, he will not find alteration necessary; but when a foreign action is fitted, he may have to shift one or two hammers a little. The jacks must next be adjusted close under the notch in the hammer butts, and this is done by turning the regulating screws; but the jack must not be raised too much or the note will fail to repeat in rapid passages. The proper position is immediately under the notch, just touching it lightly, so that the slightest touch on the key raises the hammer.

Next, the "set-off" must be seen to. The set-off of a note is the distance to which the hammer is raised by pressing down a key. In a properly regulated piano the hammer should advance to within a quarter of an inch from the string in the centre notes. In the bass it should be rather farther away, and in the extreme treble a little closer. Only experience can teach the exact ideal positions. The set-off is regulated by turning the regulating screw with a small hook till the hammer advances the proper distance.

That done, the back check and catch must be arranged by bending the wires till the check just catches the hammer and holds it for a second when the hammer rebounds from the string; this is to enable the jack to recover itself and get into the notch beneath the butt again. At the same time the check and catches must be adjusted so as to prevent the hammer from falling back too far from the string. About twice the distance of the set-off is correct, though some make the hammers fall back to $\frac{1}{2}$ in. all over the register. This must be properly adjusted or else the piano will not repeat with accuracy.

The damper action must next be seen to, and in an over-damper the wires should be adjusted by turning the buttons so that there is a play of about $\frac{1}{32}$ in. between the button and the end of the jack rocker. In under-damper actions the dampers do not often require touching, being adjusted in the shop. If, however, the dampers do not lift readily, or if they lift too much, the screw which passes through the lever end and presses the felt or leather out towards the spoon can be turned till the damper is correctly moved by the depression of a note. There should be a little space between the spoon and the lever tail when the action is at rest.

Next, the action of the pedals must be seen to, and any friction overcome by the use of a little blacklead. When all works smoothly, it is time to set about tuning the piano, be it old or new, in real earnest.

THE ORGAN

Organ building is a branch of the trade by itself. It is sometimes held to be the highest branch, but only on the grounds that the organ is the largest of instruments, for though the work in organ building must be accurate, the same exactitude in measurements is not necessary as that essential in making, say, a violin or an oboe. The organ builder, however, must add to his other qualifications that of an engineer and architect, for he has, as a rule, to build his instrument to fit some selected spot, and cannot make his instruments to any regulation shape or pattern. The trade is of such magnitude that we shall not attempt to do more than indicate the general principles followed, and we shall have to assume that the reader is a first-class carpenter to start with. Such he can become by studying the articles on that subject in this work [see CARPENTRY].

The organ builder, let us assume, has received a specification for an instrument to be constructed. The specification is a list of stops required, of mechanical accessories, and of methods of blowing, and so forth. The first thing to do is to plan out his organ, after taking measurements of the space which is at his disposal. Let us suppose that the space to contain the instrument is ample, so that he can build to suit himself to a large extent.

Now, an organ consists of bellows, a windchest, a soundboard, action for letting the wind into any particular pipe when the key is depressed, and mechanism for bringing various sets of pipes into use, and, lastly, the pipes themselves which give the notes.

The Question of Size. The size of the organ depends on the number of pipes to be used—that is, on the stops with which it is to be provided, and, if proper space is permitted, to avoid any makeshift arrangements, the general size of the organ will be regulated by the size of the soundboard, or soundboards, for the pipes stand on the soundboard. The organ may be entirely built on one very large soundboard, the great organ pipes being at the back and sides, the swell in the middle, covered by the swell box, and the choir, if there is one, in the centre and front; or each of these manuals, which are in reality separate organs, may have its own soundboard, as do the pedal pipes in most organs. So the organ builder, knowing the dimensions of the pipes of each stop, sets to work to make careful drawings of his soundboard, and so to arrive at the necessary measurements for it. Around this soundboard, or number of soundboards, the organ is built up.

The Pipes. The pipes of an organ are of two main classes—namely, wood and metal. The latter are divided into flue pipes and reeds, according as their tone is produced by a whistle-like mouthpiece or by a vibrating reed. The metal pipes are made by a special class of workmen, and are to be bought, or the organ builder makes his own from the sheet. They all have the familiar form, and differ only in length and voicing. The wooden pipes are also of two classes—namely, stopped and open. A stopped pipe gives the same note as an open pipe of double the length, and, as a rule, the stopped diapason is the most bulky of the stops placed on the main soundboards. This set of pipes, then, is first of all arranged for, and then the rest of the board divided up to suit the remainder of the instrument.

How a Wooden Pipe is Made. Making a wooden pipe is simply a matter of good carpentry. The parts are these: A foot, which is a conical, wooden tube, turned in a lathe and bored right through; a block, which closes the lower end of the pipe, and into which the foot conveys the wind to a channel cut across it; and a tube, formed of three pieces of board fastened to the back and two sides of the block, and a fourth with a bevelled edge attached to the edges of the two sides and coming just down to the top front edge of the block; and a

cap, which is a block of wood the size of the block, only broader by the thickness of the two boards. This has a wedge-shaped depression cut in it in such a manner that when applied with the hollow side inwards to the face of the block the thick end of the wedge may receive the wind from the channel and distribute it across the bevelled lip of the front pipe, producing a note. These are glued together, save in very large pipes, when the sides may be screwed to the block, and also the cap screwed on. In stopped pipes there is also a stopper which, when covered with leather, exactly fits the interior of the tube. This stopper has a handle which enables the tuner to pull it in or out at his pleasure.

With minute variations, all wooden pipes are constructed like this, though some have sides like inverted pyramids, and one or two rare stops have actual pyramidal pipes.

The Soundboard. The soundboard consists of a shallow box, divided internally into as many transverse grooves as there are notes on the keyboard, or pedal board, as the case may be. The pipes stand upon holes bored through the top of the box into these channels. The top of the box is made of two layers between which lie long strips of wood at right angles to the channels beneath, and directly under each set of pipes. The holes are bored right through the two layers and the strips, and thus it is clear that any wind in the channels can pass into the pipes above and make all sound. But if one or more of the layers be pulled out, or pushed in for an inch, a plain portion of the wood will intervene between the two bored layers, and the entire range of pipes standing above the layers thus shifted will be silenced. The drawing out or pushing in of these slips is controlled by the stops; when the stop is pulled the valves are opened, and closed when the stop is pushed back. In making this arrangement, the joinery must be perfect and the intercepting sliding parts accurately fitted lest the wind escape, and the tone of the organ suffer.

The upper table of the sound-box is conveniently made from sound boxwood, and the bars forming the sides of the grooves of good pine. The slips of wood which govern the admission of air to the ranges of pipes are cut from good pearwood, or other similar hard wood. They are termed sliders. Between each pair of sliders are strips of wood to prevent the air passing to a neighbouring set of pipes. These are termed *bearers*, and are glued between the two upper boards. It is needless to say that the upper boards need not be of the entire size of the soundboard proper, but may consist of a series of shallow boxes on the top of the soundboard, with the sliders and bearers enclosed within. This is a saving of wood. Also we need not point out that the upper board and sliders for small stops need not be as large as for heavy bass stops, such as those of 16 ft. pitch. The holes are bored through the boards, sliders, and soundboard with good centre-bits or *augers*.

To support the pipes a certain number of rack boards have to be prepared. These take the strain off the soundboard, and serve to maintain the pipe in an upright position. The holes in the rack boards have to be very much larger than those in the upper board, because they are eventually fixed on legs 5 in. above the upper boards, and so have to sustain the pipe, grasping it by the thick end of the conical mouth. Only the extreme tip enters the upper board. All holes are best scorched with a hot iron after being bored.

When the holes are bored, the interiors of the channels are well smeared with thin glue to close any flaw which may have been started in the process of boring. The sliders and boxes in which they work are best burnished with blacklead, and pins should be set in the slider cases to ensure the slider only moving its proper amount.

The Wind Chest. The wind chest is a shallow box, about 4 in. deep, or more, according to the size of the organ, attached to the under side of the soundboard. It is directly connected with the bellows by means of the wind trunk, a large wooden tube. This box contains the mechanism by which the wind is admitted to any of the channels in the soundboard, and thence to any pipe, for it will be remembered that there is one channel to each of the fifty-four notes of the keyboard, as well as one channel in the pedal soundboard for each of the pedal notes.

The width of the wind chest is governed by the length of the pallets which are to cover a great portion of the soundboard channels enclosed therein. The pallets are the wooden doors, with leather hinges which close the channels normally, and which are pulled downwards when a note is pressed. The back of the wind chest is usually made of a very stout bar of timber, called the wind bar, which helps to support the soundboard and enables it to bear the weight of the pipes.

The Pallets. To each channel is fitted a pallet, freely movable, but capable of firmly closing the portion it is destined to cover. It is kept closed normally by a wire spring, one end of which bears on a bar running the whole length of the wind chest, and the other on the surface of the pallet. The face of each pallet is covered with leather to ensure better closing of the aperture, and a ring or hook is attached to each which eventually is connected with the action of the organ. These rings are placed $1\frac{1}{2}$ in. from the end of each pallet.

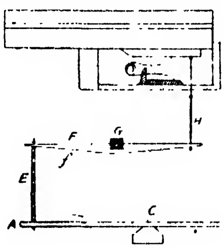
The bottom of the wind chest has to be bored at a number of spots exactly under the pallet rings and through the holes wires, known as *pull-downs*, have to pass to open the pallets, but at the same time the wind must not be allowed to escape through these borings. This is effected by fastening a piece of brass on the inside of the bottom board of the wind chest, with holes in it exactly of the size to take the pull-down wires; and along the edges of this brass slips of wood are glued to prevent any wind escaping beneath it. The pull-down wires are then passed through the board and the brass plate, and the ends attached to the pallet rings. The pull-downs must work very smoothly and never stick. All this being arranged, the open portions of the channels on the soundboard which are not covered by the pallets are covered in by gluing sheepskin or parchment over them, making an air-tight joint. The front board of the wind chest is made removable, to enable the pallets to be got at if necessary, but its joints must be made perfectly air-tight.

The bellows are not difficult to make. The form consists of three main boards for each bellows—the middle, top and feeder, as they are termed. There are also a number of thin plates of wood, known as ribs, to strengthen the sides. The whole are united by gussets of skin, and by leather hinges. The feeder must have ample room for play, according to the size of the organ, varying from 10 in. to nearly 2 ft. The upper part of the bellows, or reservoir, must also have the same amount of play, or possibly a little more. The middle board must be a little longer than the other two, so that its ends may rest upon the frame of the organ. It is the immovable base upon which the bellows work.

The middle board has a shallow box, some 4 in. deep, or more, affixed to its upper surface, or the same size as the top board. This is to enable the wind trunk to be attached to the reservoir, and is called the trunk band. In the reservoir there are sixteen ribs, and in the feeder only six, and of these last the long ribs are triangular in shape. The reservoir is made in two stages, the ribs being carried on a light frame the same size as the top board, and the folds are therefore double.

Valves. An opening is cut in the feeder board for the admission of external air, and in the middle board for the transfer of this air to the reservoir. Little bars are fixed across these openings, converting them into gratings, and valves, or " clacks " of white leather are attached thereto. The valves are best made of two thicknesses of leather glued together, and fastened at the edge by a slip of wood and a few brads, thus being firmly held down to the boards. They should fly open at the slightest pressure, and close quite flat. A valve 4 in. square should be made in the top board, opening inwards, and held closed by a stout spring to prevent over-blowing. This is opened by coming in contact with an iron rod when the reservoir is over-distended.

The wind trunks are rectangular wooden tubes, with the joints covered with leather to stop all leaks.



5. ORGAN ACTION
[For explanation, see text]

The Action. The essentials of an organ action can best be learnt from the accompanying diagram [5]; but it must be remembered that in nearly every organ various additions have to be made to these plain essentials on account of distance of sound-board from keys, and so forth, for it must be remembered that in an organ with more than one manual, however the pipes may be arranged, each manual *must* have its own perfect action mechanism.

AB is the keyboard, balanced on a pin rail near its centre, and has a pin, C, passing through a little mortise. Another pin keeps it in its place. E is a sticker, or light rod, which pushes, having wires at each end by which it is connected to AB at one end and to F, a backfall, or lever, at the other. F works on G, a backfall bridge. The other end of F, opposite to the sticker, is attached to H, the pull down, which is seen passing into the wind chest, and fixed to the pallet. This is the bare outline of the simplest possible action.

The necessary transference of motion in organ actions often necessitates the employment of rods which pull, which are then called *trackers*, and also of levers of angular form, turning between pins. These in their simplest form consist of rollers with arms projecting from them, and are called *rollers*, the frame in which they are fixed being known as the *roller board.*

The mechanism of the stops varies as much as that of the keys, and depends upon the position of the slider which has to be drawn. It resolves itself into a series of expedients for transferring the pull at the organ bench to a pull or push, as the case may be, at any given spot, and in this transference use is made of roller boards, trackers, and stickers. Only a little ingenuity is necessary to work out a scheme for any particular stop in any given position.

The pedal action is only a strong copy of the manual action and calls for no special comment.

Voicing and Tuning the Pipes. The voicing of pipes is the highest branch of the organ builder's craft, and cannot be taught save by practical instruction and by experience born of spoiling many valuable pipes. The slightest touch on the lips of a pipe may entirely alter its character. The tuning of organ pipes is difficult, but not so difficult as voicing. The tops of open pipes are cut down, a strip being taken out of the side till the right pitch is arrived at. Stopped pipes have their stoppers pushed in or pulled out till the desired result is attained, while reeds have the steel or brass rod which controls the reed knocked in or out to flatten or raise the pitch. It may be mentioned that two persons at least are necessary to tune an organ, one to manage the keys and the other the actual alteration of the pipes.

Reed Organs. Reed organs have bellows of two classes. In American organs the wind is drawn through the tongued reeds into the bellows and so discharged into the air; in harmoniums the wind is forced through the reeds from a wind chest filled by the bellows from a reservoir, as in the case of an organ. The making of the bellows in both only differs in the position of the valves, the one having the feeder with its valve to take air from the reservoir and deliver it outside, while the other has its valves in the reverse position. The spring which governs the reservoir is also reversed.

The reeds themselves in an American organ are in a frame from which they can be drawn by means of a hook. They are tuned by scraping them, at the point to raise the pitch and at the base to flatten it. Their voicing is accomplished by giving them a slight curvature. Harmonium reeds are fixed at the bottom of wind tubes leading from the wind chest, which rests on the top of the reservoir, to the pallets. They are screwed down. Their tuning is accomplished in the same manner as that of American organs, but they do not lend themselves to such varieties of voicing, the peculiar qualities of tone being obtained by variations in the wind tubes, which receive the vibrating column of air.

Miscellaneous Instruments

The accessories of the great family of orchestral instruments form a very small branch of the calling of musical instrument maker. The kettle-drums, which are really musical instruments, are built up from copper, or sometimes silver, sheets, into a form nearly hemispherical. The cubic capacity is accurately calculated for the note which the normal kettle-drum is to emit. Cymbals are beaten out of hard brass, and require much skill in tuning. The size of the central depression has to be accurately gauged or a pure tone will not result.

MUSICAL INSTRUMENT-MAKING *concluded; followed by* THE BUSINESS SIDE OF AMUSEMENT

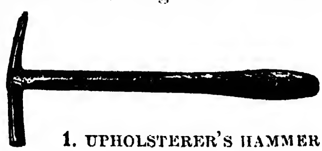
THE UPHOLSTERER'S WORK

The Tools and Materials of the Upholsterer. Stuffing Chairs and Couches. Making Mattresses and Bedding. Hangings, Carpets, and Linoleum

Following CABINET-MAKING from page 6591

THE work of upholstery may be divided into two classes—that which comprises the stuffing of chairs, sofas, and other articles of furniture, and that which concerns the arrangement of hangings. The former class demands chiefly the exercise of manual skill; the latter affords greater scope for the artistic faculties. We shall consider first the former class—that of furniture stuffing.

Upholsterer's Tools. The tools of the upholsterer are not numerous. The hammer used is light and of peculiar shape [1]. It usually has a claw at one end of the long head. A claw hammer of American or Canterbury shape [see page 3388] is also used. Then there is a special form of pincers used for stretching cloth [2] and sundry accessories such as upholsterer's needles, scissors, light or heavy according to the work in progress, a mallet, a bradawl, a ripping chisel, a screw driver, a pair of compasses, a rule, and perhaps a tape measure. The needles used by upholsterers are of special forms. The ordinary straight or bent packing needle is used for rough sewing. The proper upholsterers' needle is an instrument from 8 in. to 10 in. long, pointed at both ends, and with an eye near one end. For stitching up and mattress work a special needle bent to the shape of a semicircle or crescent shape is used. It has one sharp end only, the other end containing the head.



1. UPHOLSTERER'S HAMMER

The stud gauge is a small hand tool somewhat resembling a miniature daisy fork. The prongs, which are three in number and equidistant, are used to mark the places for the brass chair nails or studs put in round the edges. For ordinary studs—say $\frac{3}{8}$ in. in size—the prongs are usually $\frac{1}{2}$ in. apart. Web strainers, which are used to stretch the webbing tight before tacking it into place, are made in several forms, and one or other must be used if good work is to be done. The upholsterer's regulator is a pointed instrument slightly curved at one end and hafted at the other; it is used for working the stuffing into the corners during the stitching up. The stuffing stick, which is used for mattress making, may be made from a piece of hardwood about 30 in. long. One end is made fish-tail shape, and the remainder is rounded to make it convenient to hold in the hand.

A hair teaser is a machine which may be installed by the upholsterer. Its chief value is in repair and cleaning work, but it is used also to open out hair-stuffing from the rope in which it is bought. Flock and hair may also be teased by the use of hand carding combs, two flat boards thickly set with teeth and caused to move backwards and forwards with the material between, thereby teasing it out.

Upholsterer's Material. The materials used by the upholsterer are limited in number. Upholsterer's springs are used for the interior of chairs, etc. Their manufacture has been described on page 5173, but the upholsterer never makes them himself. The usual sizes used are 5 in. for the scrolls of couches, 6 in. for small chair seats, 7 in., 8 in., and 10 in. for couch and sofa seats and backs, and for easy-chairs. Chair webbing, or girth webbing as it is sometimes called, is used extensively. It is from $1\frac{1}{2}$ in. to 3 in. wide, and is an inextensible band of strong, closely-woven canvas. Then there is thick canvas for covering the springs, twine and scrim for covering the hair for first stuffing. Tacks and gimp pins—a small variety of tacks—are also used. Apart from these there are only the stuffing material and the covering material.

Stuffing Materials. The several materials used by the upholsterer for stuffing we shall describe briefly in catalogue order.

Horsehair is still an important filling material used by the upholsterer. It is supreme from the point of view of elasticity. The best qualities are used for filling mattresses, medium qualities for general work, and the cheapest varieties for rolls, or for inferior work. It is usual to lay between the hair and the covering material a layer of wadding, with its soft side towards the hair. This takes away the harsh feeling of the hair, and it also prevents the hair from working through the covering material. Hair is sold in rope form, and it must be teased out before being used as stuffing. Sometimes this is done by hand, as the machines used for the purpose are alleged to break the hairs, but machines are generally employed. The machine used by upholsterers in this country is a rotary machine consisting of a roller covered with spikes that tear the hair from the rope form. The machine employed on the Continent consists of a swinging quadrant furnished also with teeth, the thrust and pull working of the operator separating the hair as it is passed through.

Feathers are used as a filling material chiefly for mattresses. It is a mistake to use too cheap feathers, as they are not relatively so cheap as price would indicate; the better feathers are more elastic and fill more space, hence a smaller quantity suffices.

2. STRAINING PINCERS

Rabbit down is sometimes used as stuffing for very cheap work, but it is frequently verminous, and it is now seldom demanded. Flocks are common stuffing materials, and may be had in a wide range of qualities, and at prices from $1\frac{1}{2}$d. to 10d. per pound. They are the waste of the weaving factory, the best being waste from fine wool, and the lowest grades coming from the screening of cotton-cleaning machines. The best stuffing wool is white wool, which has a good curl, and is very elastic. It does not mat easily, and this is the factor of prime importance.

Flocks are sold in bags usually of 50 lb. or 56 lb. Their field is chiefly for cheap work, and only the washed varieties ought to be used. The upholsterer may save money by introducing cheap materials as stuffing, for the work is not open to inspection, but this is fatal to a good reputation and a permanent connection. Among the vegetable fibres used for filling—chiefly for cheap work—are cocoa fibre, Mexican fibre, Algerian fibre or Crin Végétal, and

alva, or alfa, a variety of sea weed which moths avoid. A superior material has recently come into use in kapok, a short-stapled vegetable wool which is of no use for wearing, but makes an excellent soft filling material. It comes from Java and India; its market price is about 7d. a pound, but under the name of "vegetable down" some dealers have made a little mystery about it and sold it at very much higher prices. The twine generally used for upholstery work are specially made. Stitching twine is thin and tufting twine is thicker. They are sold in ¼ lb. and ½ lb. balls.

Covering Materials. Important among the covering materials used by the upholsterer comes leather in several varieties. Morocco leather, or *levant*, as it is sometimes called, is the best, and owes its acceptance to its durability and its retention of its colour. It is the skin of the goat, and the sizes of the skins run from 25 in. to 35 in. wide. Roan, which is sheep skin, is much cheaper, and usually measures 30 in. to 38 in. wide. In appearance it is not easily distinguished from morocco leather, but it soon becomes shabby, and its chief sphere is for backs of chairs when the fronts are covered with morocco. Roan is elastic, and much easier to work than the more expensive morocco. Hair-cloth, the use of which is less common than formerly, is possible only for plain seats, as it cannot be plaited. The chair, or other article, is finished in holland or black canvas before the hair cloth is put on. Hair cloth is procurable in several widths from 16 in. to 30 in., but the price per superficial unit is much higher as the width increases, hence cloth work is commonly welted, thus making narrower widths workable. Hair cloth is generally black, and is made by weaving a horsehair weft—already dyed black—with a black linen warp. As a material it is very durable, and is not given to fade, but it is liable to retain a good deal of dust in its open texture.

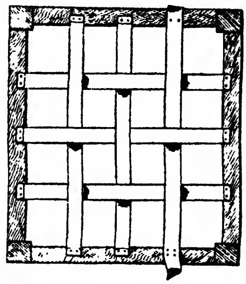
American leather cloth, or Crockett's leather, can be had in a wide variety of shades and surface markings. It has extended use in cheap work, and is valuable in being waterproof. The body is calico, and the surface is a waterproof composition. The usual width is 45 in.

Velvets—both genuine and imitation—are used in upholstery. The standard width is 24 in. Variation of the surface gives different kinds that are sold under specific names. Thus stamped velvet is passed through a rotary press and given a surface design. Utrecht velvet is made from mohair, and is heavy in pile and texture. Frieze velvet has a surface with small loops left uncut. Velveteen is a short-pile cotton velvet.

Plush is a variety of silk-pile velvet, and used to be much more frequently used in upholstery than it is to-day; plushette is a cotton imitation.

The covering materials used in upholstery are very numerous, and are constantly being added to. Fashion changes rapidly; one variety of expensive material may be adopted extensively by the highest-class trade, and will reign until manufacturing enterprise puts on the market an inferior and cheap imitation, and then fashion elects another queen.

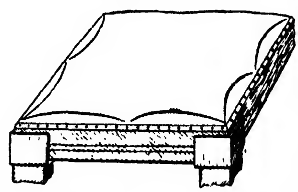
A Stuffed Chair. A chair is at once the most common and the easiest article of furniture to stuff, and it is therefore proper to consider it first. We shall take a small chair to be stuffed with hair and covered with leather. First take a roll of chair webbing, and having doubled over one end half an inch, drive some tacks through the doubled over part, thus tacking the end to the under side of the chair frame. Strain the webbing well and put two tacks into the other side of the chair frame, thus making a piece of webbing go right across the frame. Cut the webbing about 1 in. beyond the second tacks, then double this 1 in. over, and put some tacks through the double part. Use ⅝-in. tacks. Proceed until you have three lengths of webbing from front to back, and three from side to side [3]. Interlace the front to back pieces with the side to side pieces—that is, pass them over and under, as is done with the laths of a metallic bedstead. The spaces between ought to be of about equal size.



3. WEBBING OF CHAIR BOTTOM

Next, take five chair springs (6-in. size), and fix them with twine to the webbing. Let them be about equidistant from each other, and well towards the middle of the seat, not up to the edge of the chair frame. Then, to the top of each spring attach a piece of lashing twine, and tie the springs down so that they are not extended fully, but are compressed to, say, about 4½ in. high. In doing this, take care that the springs are quite upright. Take a piece of canvas and stretch it tightly across the top of the springs, securing it to the chair frame with ⅝-in. tacks. Then, using the bent needle, sew the top of each spring to the canvas, so that in use the springs will not be dislodged from their upright positions. In sewing, use about five or six stitches to each spring, and knot securely each stitch separately, so that if one stitch should come undone, it will not affect the others. So far, the work has been preparatory to stuffing. We now come to the stuffing proper. This is a double process, consisting of the first stuffing and the second stuffing.

The First Stuffing. For the first stuffing, run a string round, in long stitches, about 2 in. from the edge of the seat [4], and string on a fair quantity of hair. Avoid putting too much in the middle of the seat, especially if the seat has to be buttoned. Now, scrim—a variety of coarse muslin—is put over the hair and tacked into place temporarily.



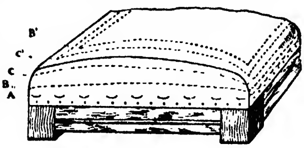
4. CHAIR READY FOR STUFFING

Stitch the scrim to the canvas, stretched over the springs and below the hair, using a double-pointed upholstery needle, and making the stitches about 3 in. long and about 4 in. from the edge of the chair all round. This leaves an outer edge right round, separated from the middle portion by the stitches. The temporary tacking round the edge must now be undone—a little bit at a time for preference—and the edge must be tightly packed with hair, using the regulator as an aid. Then having doubled over the edge of the scrim, tack it firmly all round.

We now stitch the edges of the seat. The purpose of the first stitches will be to secure the hair in the edges firmly, so that in use there will be no likelihood of it getting worked out of place into the centre of the chair. Thread the long, straight, double-pointed

needle with twine, and push it through from the front, just above the front rail, so that it will emerge from the top of the seat about 6 in. back. Pull the needle out a little, but not altogether, and changing its direction a little, send it back again to come out at the front, about 1 in. from where it entered. There is now quite a body of hair contained within the twine loop made in the inside. Pull the needle out at the front, and pull the twine very tight. Go on making stitches in this way right round the chair. Let the stitches be about 2 in. apart. They will be visible only in front [A in **5**], as the twine has not been carried out through the top of the seat. This form of stitching is called *blind* stitching. In sewing as described, try to get as much hair as possible, and to get as nearly uniform a quantity as possible into each stitch.

The second stitching is similar, but it is made to go right through the seat. Begin by entering the needle at the front, 1 in. higher than the first stitching [B in **5**], and draw it out at the top about 2 in. from the edge of the seat [B′]. After withdrawal, enter it again about 1 in. along, and at the same distance from the edge of the seat. Continue stitching in this way, making 1 in. stitches, and pulling them as tight as possible, until the front and the sides are all stitched. In a small chair, the back may be left with only the first stitching.



5. SEAT STITCHING

The final row of stitching may now be put in. It is similar to the second row, except that it takes in much less of the scrim and of the hair. Begin higher up in front than formerly [C], only $\frac{1}{2}$ in from the top, and come out on top only $\frac{1}{2}$ in. back from the edge [C′]. Having done this, the first stuffing is finished. If it has been properly done, it will be about 3 in. higher than the chair frame; it will overhang the frame a little, and will be packed to a uniform stiffness all round the edge.

The Second Stuffing. Now comes the second stuffing. If the seat is to be buttoned, draw a centre line on the scrim from front to back, and with this as a guide, mark places for ten buttons. The buttons will be in four rows, from side to side, alternating two and three buttons in the row. Thus, the front row will have three, the second row two, the third row three, and the back row two buttons. No button must be placed nearer than 3 in. from the edge of the seat. See that all the places for buttons are equidistant in the same row, and that the rows are at equal distances apart. With scissors, cut a small hole in the scrim where each button is to be, so that the place may be felt when the hair has been picked on.

We now take the skin with which the chair is to be covered. It must be marked for the buttons. Place it on the top of the scrim with the neck part towards the back of the chair, and mark and crease it into diamond-shaped squares. The extra size allowed for each diamond is usually $1\frac{1}{4}$ in. more than actual size, to allow for fulness in stuffing, but if the buttons be wanted very deep, as much as $2\frac{1}{2}$ in. may be allowed. If the skin has any flaw, it may be possible to make this go into the fold of a plait, thereby concealing it.

The skin having been marked and creased, the hair of the second stuffing is placed on the top of the scrim. A sheet of wadding, cloth side downwards, is laid on top, and upon the whole the skin is placed. The buttons are put into their places by means of string, with a slip knot. The hair is sloped away from under the buttons, which are pulled halfway down. The string is then tied, and the ends are cut off. Now, with the fingers, make the plaits lie regular and smooth, and make the stuffing even and uniform in thickness, so as to give symmetry of form to the seat. Pin the skin to the edge of the first stuffing, and cut off the skin to the exact size, leaving about $\frac{1}{2}$ in. all round for doubling in the edge.

Covering the Stuffing. The cuttings from the skin go to form the bordering all round the seat frame. For leather seats, the borders are usually attached with studs having heads covered with the same leather as the seat. If the studding be very close, border may not be necessary. The strips will not be sufficiently long to go round the sides and front of the chair frame, and there will probably be two joins. Let these be at the sides near the front corners, overlapping them about $\frac{3}{4}$ in. The border must be cut neatly with a sharp knife. Cut it about 1 in. wide, and double it back at both edges, so that the strip is $\frac{1}{2}$ in. wide, with the two edges touching, or almost touching, at the back. Thus, the exposed edges will be folded, and will not show the back of the leather. The joint should be made with glue that is not too hot, so that it will not penetrate and discolour the leather. The stud gauge will be used to mark the places where the studs or ornamental nails will be put in.

For the sake of clearness we have considered throughout a chair seat of horsehair, leather covered. Other stuffing is manipulated in the same way, and in any other variety of covering the same process is followed. American cloth ought to be warmed slightly, especially in cold weather, as otherwise the handling may cause it to crack. When the seat is to be plain and unbuttoned the instructions regarding the buttoning are, of course, not followed. When material other than leather is used for covering, the bordering used is gimp, a narrow, ornamental border of a colour to match the covering material. This is secured in position with gimp pins, a variety of small tacks. Now the underside of the seat may be covered with canvas tacked to the frame and hiding the springs.

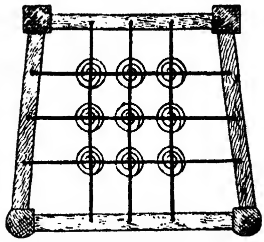
Upholstering a Chair Back. The back of a chair, if it is to be upholstered, is done much in the same way as the front, and as we have described. The interlaced webbing is attached and stretched to the frame, the springs are fixed—if springs are to be used—the stuffing is strung on, the layer of wadding is placed on top and the skin is attached as already described.

If the chair seat is buttoned, the back is both buttoned and tufted. The buttons are strung on, and the two ends of the string drawn through to the back of the chair, and tied over tufts, which are scalloped washers as used for mattresses.

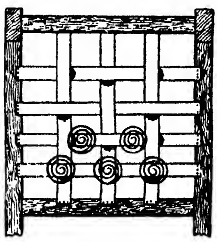
Stuffing an Easy Chair. An easy chair usually has a stuff-over frame—that is to say, the whole of the woodwork may be covered with upholstery except the legs. The frames are usually of beech or birch, the latter being the better, and the legs of mohogany or other superior wood.

The bottom is first webbed, say with six strands of webbing each way, then the back is webbed, the webbing for the back being attached to the front of the frame. Then the springs are attached. Four 6-in. springs are used for each arm, being attached with wire staples, or by any other convenient way, and no webbing being used. The seat will require 9 springs (8-in. size), and the back

5 springs (6-in. size). The seat and side springs are sewn to the webbing as described for the small chair, the side springs being in two rows, a lower row of three and an upper row of two. The seat springs are lashed with cord, that is to say, laid cords are tacked to the frame and passed round the top coil of each spring, there being a lashing cord for each row of springs from back tofront, and another lashing cord on each row from side to side, as seen in 6. The effect of this lashing is to compress the springs slightly, and to cause them to stand up about two-thirds of their natural height. If the work has been done properly, the springs will incline with their tops towards the front, so that when the seat is sat upon they will be vertical. We then give the back a little attention. We have already attached the five springs to the webbing [7]. From side to side we sew a piece of hessian to the horizontal strand of webbing just above the upper row of springs, then we pull the hessian tightly over the springs, compressing them a bit, and tack the hessian to the lower edge of the back frame, thereby retaining the springs in compression. Take another piece of hessian wide enough to cover the row of arm springs already in place. Tack this hessian to the inside of the arm rail, pass it over the top of the springs and pull it tight, compressing the arm springs in their turn, and tack the hessian to the outside of the arm rail. Treat the other arm similarly, and we are ready for the stuffing. Horsehair, flock, or alva may be used; if the first named, it may be of second quality. Put long loop stitches round the edges of the seat, and pull the loops fairly evenly with the stuffing. Cover the stuffing with scrim, which must be tacked to the edge, then put in more stuffing, using the stuffing stick, until there is all round the seat a roll similar to that we saw in stuffing a small chair. Then do the first and second stitching as described in our initial attempt and put the third row of stitches only in front, and up the sides as far as the arms, but not under the arms, and not along the back of the seat.



6. SPRINGS LASHED DOWN



7. EASY CHAIR BACK WITH SPRINGS

Easy Chair Arms and Backs. The back of the chair is sewn with long loops of twine, and stuffing is strung on under the loops. The swell at the bottom should have a much larger quantity of stuffing than higher up if the seat is to be comfortable, as this part goes into the hollow of the back of the person using the chair. Cover the back stuffing with scrim, and the first stuffing of the back is complete. We now stuff the arm bolsters—that is, the portions under the arm rails. These should be well and firmly stuffed. Sew on loops of twine as elsewhere and when the stuffing has been put on, cover with scrim. An equal quantity of stuffing must be put into each bolster or the result will not be uniform, and this caution applies particularly to the arm rail stuffing. The arm rail or bolster head, as it is called, may now be negotiated. Tack the end of a piece of scrim to the under side of the rail, and having stuffed it well, bring the scrim right round over the top of the roll and tack the other end down to the under side of the rail. In stuffing the arm rails, let the front parts be more firmly stuffed than the back parts, as the front requires to have greater resistance in use. Tack the scrim down at the back, and sew the front of the rail roll with two rows of stitches similar to those in the first stuffing of the small chair.

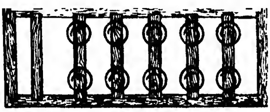
The second stuffing of the seat is done in the same way as we have described for the small chair. The material is strung on to the scrum within the rows of stitching and is made higher in the centre of the seat. Then the layer of wadding is placed over this, and the covering is put on top. In good work, a covering of calico, well stitched and made free from wrinkles, is placed below the leather or other covering, and tacked to the frame. After putting on this calico, the seat should be sat upon to see if it is all right. It will be found whether or not it shows sufficient firmness; if too yielding and slack, more stuffing should be put in, which means undoing the calico for the purpose. The other parts of the chair—the back, the arm bolsters, and the arm rails—are treated in similar fashion. Then the covering material—leather, velvet or other material—is fitted and attached, and the arm-chair ought to be a thing of symmetry and comfort.

Saddlebags. Saddlebags are properly of Persian carpet, and are very expensive. The name is now usually applied to squares of Wilton carpet pile which are used extensively by the upholsterer. They are square, and are put on the market in two sizes, 18 in. and 22 in. By sewing them to velvet surrounds, they have the appearance of panels, and thus used are widely employed for easy chairs such as we have just considered. Such a chair requires four saddlebags—two 22 in. for the seat and back, and two 18 in. for the arms. There is room for skill and ingenuity in cutting out the surrounding cloth so as to avoid waste, and with plain surrounds this is not very difficult, but with figured velvets it is much more difficult, because the pattern of the surface must be made to match, thereby limiting the freedom of action. Before cutting and sewing the surround to the saddlebags, sizes must be taken carefully. The width of the seat and sides between the bottoms of the stuffing rails at both sides must be measured exactly. Add 1 in.—an allowance for seams—and subtract the width of the saddlebags. By halving the result we have the width that the surround at each side must be. Similarly measure the chair from front to back, make the 1 in. allowance, deduct the width of the saddlebag, and halve the result; this gives us the width which the surround at front and back must be. The surround should be cut from the piece straight across the cloth; both strength and appearances require this. Now place the surrounds on a table with the saddlebag in the centre, and when they have been adjusted to their proper position, sew them together. This having been done, the seat is covered. Care must be taken to have the saddlebag right in the middle of the seat, and the cover is then tacked on. No wrinkles must be allowed to appear, and there must be no undue straining at any part or the balance will be upset, and the result will be uneven. The back and bolster arms are treated in the same way, care being taken to do the work evenly; more stuffing may be inserted or some stuffing may be taken out if it will conduce to this result. The back of the chair behind is usually covered with plain cloth

similar to that used for the surrounds of the saddle-bags, or a cheaper material of the same colour may be used. The bordering for the seat will be of a suitable nature and colour for the covering; sometimes a deep fringed bordering is used. The ends of the arms and head are often finished with tassels and cords, the colour matching the covering. The bottom of the chair underneath should be covered with cloth—usually black linen—put on over the webbing, and attached to the frame with tacks.

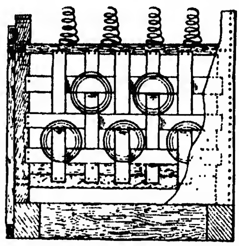
Couches and Sofas. We now come to the consideration of sofas, couches, and ottomans. A sofa, of course, is a long seat, with a back and two ends or arms. Remove one end and slope the back at one side, and we have a couch. Now take away the back, leaving the seat with only one head or arm, and we have an ottoman. A sofa has the back upholstered like the back of an upholstered chair, but a couch often has the back open with merely an upholstered top rail. Couches are commonly left-handed, which means that a person reclining on one and facing the front would have his left arm free and be reclining on his right side. The old English style of sofa has very steep ends, so that a pillow is necessary to comfort, but the present fashion is towards the German style of arm, which slopes away at a more obtuse angle, and is at once more comfortable and more graceful. The practical effect of the construction of the latter type is that the pillow of the English style is introduced into the upholstery itself, rendering the extraneous article unnecessary.

Upholstering a Couch Seat. Let us upholster a spring seat couch with a serpentine back—that is, a back which in profile is like a camel's two humps, that further from the head much lower than the other. The seat is the first part to which we give our attention, and before we upholster it we must remove the back from the frame, which will not be difficult, as it will be found to be attached by screws. We shall not use webbing, as we did with the small chair and the easy-chair, but rails of wood attached to the front and back of the seat frame by their ends. There will be six of these cross rails, arranged so that the daylight spaces are equal. We do not put springs on the rail at the head end, but on every one of the others we put two springs [8]—one towards the back and one towards the front—and fix them with staples. Tack a length of hessian to the front of the frame, strain it over the springs, compressing them to two-thirds of their natural height, and tack the hessian at the back of the frame so as to keep the springs compressed. Sew the top coil of each spring to the hessian, seeing that their final positions are vertical. With the curved needle put long loops of twine along the front edge, along the bottom edge, and along the back at its edges. Pack under these loops stuffing to the thickness of 3 in.—fibre or rag flock, not the mattress varieties of flock. We have now a border of stuffing all round except at the head. Fill up the middle part with flock, making it higher in the centre than elsewhere. Tack a piece of scrim all along the front, fold it right over to the back, and tack it to the back rail in the centre of its length. Then tack down the whole to the back rail, working from the centre. Do not pull up the scrim too tightly when doing this, but let it be stretched evenly, and see that the stuffing is fairly uniform as the work proceeds, remedying any shortcomings in this direction with the stuffing stick or regulator, and withdrawing or adding flock if necessary. The front, back, and bottom end may now be stitched—in a manner similar to that followed in the case of the easy-chair—with first, second, and third stitches.



8. COUCH BOTTOM WITH SPRINGS

The Couch Head and Back. The frame of the head consists of covered scrolls at each side, connected with cross rails, probably four in number. Tack webbing to the face of the cross rails—say three lengths, straining it as already seen. Then interlace cross webbing and tack it to the side scrolls. Attach the springs in the usual way, using five in all, a lower row of three and an upper row of two. Then attach four springs to the top rail at right angles to the other springs, all as illustrated in **9**. Cover now with hessian, attaching it to the side scrolls, and string on twine loops, filling the loops with stuffing. Cover the whole with another piece of hessian, tacked to the bottom cross rail and at each side to the side scrolls, pack the stuffing uniformly, and not too firmly into the bag thus formed, and sew the whole up complete.



9. SPRINGS FOR HEAD OF COUCH

The couch back will probably have upright rails. Web it horizontally, and interlace intermediate webbing vertically. Attach twelve 4-in. springs, cover with hessian, loop up, pick on the stuffing, and cover with hessian again as for the other parts of the couch, finally sewing right around the curved edge with first and second stitching. The covering remains to be attached.

Covering for Couches. If skins are used for covering couches, they must be sewn together because one is not large enough. Three skins are always required, and sometimes part of another as well. If the couch seat is not to be buttoned, cut the skins quite straight so that the seam will be at right angles to the line of the front rail, and sew them neatly together with a small welt. The sewn skins must be cut to shape upon the couch itself. Tack the cover on at the front rail first, then beginning in the centre, strain the covering back and attach to the back rail. Work along from the centre until the whole couch is done. If the seat is to be buttoned, the skin must be marked for the buttons as already seen for the small chair. The front row of buttons should be 3½ in. to 4 in. from the front of the seat, and the diamonds of the buttoning should be marked 7½ in. from side to side and 9 in. from front to back: this, with the allowance necessary for fulness, giving diamonds 7 in. from back to front and 5 in. from side to side. If the depth of the couch from front to back is greater than the width of one skin, another skin must be sewn to the first, so as to give the necessary width. The edges to be sewn should be cut to a diamond, pointed zig-zag shape so that each point will fit into a corresponding angle. To mark the buttons for the head of a couch is a complex task, and can be done properly only by the experienced man whom practice has instructed. The allowance for fulness in the diamonds must be increased the further up the head the work is carried on. This increase is usually 1 in. more for each diamond than for the diamond immediately

below it, and is caused by the curve of the head demanding an allowance in addition to the of the individual diamonds.

Bedding Manufacture. The manufacture of bedding falls within the scope of upholstery in the widest sense of the term. The stuffing of a mattress is hidden just as is the stuffing of a piece of furniture, and there is even more imperative call that absolutely clean materials should be used. Vegetable fibres such as cotton flocks and alva do not attract moths; hence they are generally healthier than feathers and wool. Horse-hair is considered the healthiest material, however, as it is a better heat conductor than other materials and does not retain the body heat of the sleeper. Horse-hair for mattresses should be short and curly, and if suspicion be entertained that it has been adulterated with vegetable fibre—rather a common practice—it may be tested by burning it, as horse-hair burns to a black ash and vegetable fibres to a grey ash. If wool be used for mattress stuffing, white wool is the best, but it is also the dearest. The temptation of the upholsterer to use inferior stuffing is very great in these days where such a large share of the trade depends upon competition in price. Sometimes both hair and wool enter into mattress filling, the hair being in the centre with a layer of wool below and above, also at the sides and ends, the object being to secure the springiness of the hair combined with the softness of the wool. Such mattresses are known as "cased" or "French." The hard, straw-stuffed mattresses used under the hair or wool mattress are called *palliasses*. Their purpose is to protect the mattress proper from the hard wear which would come by placing them direct contact with the bed laths.

An ordinary mattress of 6 ft. by 4 ft. size contains 48 lb. of best hair, 54 lb. of medium quality hair, or 54 lb. of good wool stuffing. Mattresses should be opened and have the stuffing material thoroughly cleaned and teased at periodical intervals, say, every two years at least. This is a detail regarding which the majority of English people are too indifferent; in some other countries householders are much more alive to its importance. In France, for instance, a common feature of the household spring-cleaning is that bedding cleaners visit the house and open, clean, tease, and refill the bedding.

Stuffed Mattresses. The most common variety of mattress is the stuffed mattress, and we shall consider the manufacture of one of the size mentioned above—to wit, 6 ft. by 4 ft, which is the size sold in largest numbers. The covering is ticking, a strong material which may be had in various colours and patterns. It is usually cotton, and is mixed in the cheaper qualities. Linen and jute cloths are also used, chiefly for hair mattresses. Coloured ticking is known as fancy Belgian. Drill is a variety of ticking, and sateen is another variety with a lustre caused by the methods adopted in finishing. To bind the mattress together, mattress ribbons, which are to be had in patterns and colours to match the coverings, are used. Then mattress buttons are to be had in any colour to match the covering material. Mattress tufts are stamped circular pieces of leather, leather, or woollen cloth.

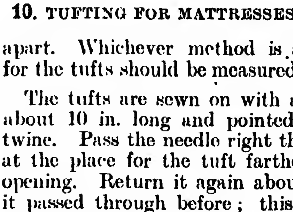
The cutting-out is the first operation. The tying down of a mattress uses up some cloth, so in cutting the cloth we must allow for this. The usual allowance for a hair mattress is 1 in. for every foot of length and ¾ in. for every foot of width, so that the upper and under surfaces of a 6 ft. by 4 ft. mattress will be 6 ft. 6 in. by 4 ft. 3 in. If wool is the stuffing material, the allowance is not quite so great. Having cut the main pieces, cut out the borders, or sides. They must be cut from across the piece so that the stripes will run up and down in the direction opposite to the stripes on the face of the mattress. Make them 6 in. wide and 6 ft. 4 in. long, the odd 4 in. being allowance for sewing. The border for the ends will be similar—4 ft. 4 in. long by 6 in. wide.

Sewing the Mattress. Now, with the sewing machine sew the large top piece to the four borders all round it—the seam being ¼ in. from the edge of the material—so that the edges come to the outside of the corners of the mattress. Take a roll of mattress ribbon—an entire roll contains 144 yds.—and sew it over this seam with the sewing machine, and through the double thickness of the ticking. The corners are not sewn up to a sharp angle, but are slightly rounded.

The bottom piece is now sewn to the side pieces—at the free sides of the latter—leaving, however, about 20 in. unsewn at one end to be used for filling the case. The ribbon is sewn over the seams round the bottom piece in the manner already described, and the corners of the borders—where the side pieces join the end pieces—are sewn from the inside with a needle and thread.

The stuffing material is now put into the case, through the opening left for the purpose. Put in a small quantity to begin with—say 10 lb.—and with the help of the stuffing stick push it well into the corners, but do not press it too firmly. Add more stuffing, distributing it evenly over the whole space, and see that the mattress comes up square, with the sides in their correct relation with the top and bottom surfaces. In this way fill about three-quarters of the mattress case.

We now tuft the mattress, that is, sew it through and through with stitches held by a tuft at each side. The tufts may be in rows parallel with the sides and ends of the mattress, which gives the appearance of squares, or they may be arranged as in the buttoning of an easy chair, in which event they will give a diamond-shaped appearance [10]. The latter looks better, but the former makes the mattress more easily rolled up for storing and transit. The tufts are usually 6 in. apart. Whichever method is adopted the places for the tufts should be measured out properly.



10. TUFTING FOR MATTRESSES

The tufts are sewn on with a mattress needle—about 10 in. long and pointed at each end—and twine. Pass the needle right through the mattress at the place for the tuft farthest from the filling opening. Return it again about 1 in. from where it passed through before; this will show a stitch about 1 in. long. Place a tuft under this stitch, make a slip knot at the other side and insert a tuft here. Now pull up the string tight until the tufts are drawn together and sink quite an inch into the stuffing, then tie it firmly and cut it off. Proceed with the other tufts in the same manner, until almost as much of the mattress as is filled has been tufted. Fill the remainder of the mattress, sew up the opening that is left, and finish the

tufting. The mattress is now finished; it should be firm and its appearance regular.

For hair mattresses a stronger ticking is necessary than that used for wool; it is usual to employ linen ticking, as this prevents the hairs, which are comparatively sharp and penetrating, from making their way through the cloth.

Feather Beds. Feather beds are mattresses filled with feathers instead of hair or flock, and are not tufted. The feather bed, if of good quality, will be bordered and welted, as we have described in the manufacture of mattresses; but many are made without border, the case, in that event, being merely a large sack of ticking. Feathers have the power of penetrating the cloth, and this tendency cannot be entirely eliminated, but it may be minimised by waxing the inside of the ticking, the waxed surface offering a smoothness which the feather stem finds difficulty in piercing. A feather bed 6 ft. long by 4 ft. wide requires about 48 lb. of feathers, and one 6 ft. 6 in. long, demands about 52 lb. of feathers.

Upholstered Spring Mattresses. The box spring mattress, or upholstered spring mattress, is a mattress consisting of a wooden frame with a bottom of wooden laths or webbing, upon which are mounted spiral springs, surmounted by a stuffed superstructure. For a box spring mattress of ordinary size the wooden laths usually number six, and are placed across the frame. To each lath six 10-in. springs are attached by wire staples, or, if the laths be replaced by webbing, by sewing. These springs are lashed down by having twine strung across their tops. Over the top is placed a piece of hessian, and all round the side, but not at the top; the hessian is formed into a roll about 8 in. wide, which is stuffed with cocoa fibre or other coarse stuffing material. This roll is securely stitched, and when finished forms a semicircular pad close to the edge of the mattress frame all round the sides and bottom. Now cut the top cover, which will be 2 in. larger than the wooden frame and 1½ in. wider. Put stuffing all over the hessian which covers the springs, and over this put the top cover; tack it into position all round, and tie it down, tufting it in the way already described. Short pieces of webbing may be nailed to the seams of the frame near each end so as to form handles by which the mattress may be lifted. Now cover the entire bottom with a piece of hessian.

Certain precautions should be observed in making a box-spring mattress. There is a temptation to make the centre too high, as is customary in stuffing chairs, but a top that is perfectly flat is far preferable.

Webbed Box-spring Mattresses. Another style of box spring mattress is made without bottom laths, but with webbing above and below the springs. A box frame, consisting of sides only, would be rather weak, and two cross stretchers must be used to impart strength. The webbing is put on in the usual way, 3 in. spaces being allowed between the lengths. It should be strained well. The springs—of which there will be 30 to 36 in a mattress of 6 ft. by 4 ft.—are 8 in. high, and of No. 10 wire gauge. Care must be taken to have them upright before being attached to the upper webbing, which is put on tightly so as to compress the springs. We have now got a wooden frame with interlaced webbing on both upper and under sides, the space between the webbing being occupied by springs. Place over the top webbing one piece of hessian to cover the entire surface, and tack it to the wooden frame. We now cut two side pieces and two end pieces the exact length of the sides and ends of the frames, all being 6 in. wide. Sew these pieces to the hessian 4 in. from its edge; then we shall have a loose flap all round the hessian. Tack the unattached edge of this hessian to the wooden frame all round, thus forming long channels all round the four sides of the mattress. These channels must now be filled with stuffing—fibre or flock—and will form a thick roll all round. String on stuffing about 3 in. thick to the top surface within the rolls just formed. Cover this with hessian, which tack to the side frames all around just beneath the edge of the rolls. Now make a top cover of sateen ticking, giving it a 6-in. deep border for sides and ends, and sewing it up and binding it with mattress ribbon, as already described in making the ordinary stuffed mattress. Having made the cover to fit the frame, pull it on and tack it beneath the wooden frame. The whole is now tufted in the usual way; and after having had the under surface covered with hessian, the box spring mattress is complete.

Spring-framed Mattresses. A spring-framed mattress is another variety which resembles somewhat the box spring mattress, but its manufacture is work for the carpenter rather than the upholsterer. Also it is being discarded in favour of less cumbrous arrangements. Two rectangular wooden frames are made and are lathed with wooden straps. Turned conical guide blocks are nailed at each crossing of the laths. The guide blocks in the lower half look upwards and those on the upper half look downwards. Mattress springs are put over the guide blocks, the cones keeping the springs in the proper positions, and wire staples are used to retain them, four staples being driven in around each bottom coil. The whole may be covered with mattress ticking, or the sides may be left open. In use, this type of mattress has always an overlay mattress on top, but the wire-woven spring mattress has displaced it, and will no doubt eventually oust it altogether.

Palliasses. The palliasse, or straw-filled mattress, is used underneath the ordinary or overlay mattress. Its object is to protect the mattress proper from contact with the metal laths of a bedstead, but the introduction of the wire mattress affected the extent to which palliasses were used, and they are now becoming less common. Palliasses are usually made in two parts, divided right across the length, so that a palliasse for a 6 ft. by 4 ft. bed consists of two halves, each 3 ft. by 4 ft. The case is usually of canvas, with a border of ticking on three sides, that side which butts against the other half being of canvas. The case is bound right round. The border is not so wide as for an overlay mattress, being only 4 in. Straw is the best material for filling. It is frequently used as it comes from the bale, but ought to be twisted up and broken before being used. Straw that has been used for packing goods makes, if clean, excellent filling, as it is usually well broken. The case is made by sewing the tick border to the hessian cover with strong linen thread, well waxed. After being filled and sewn up, it should be beaten well with a heavy stick to make it quite flat. It is now sewn right through, as in tufting, but tufts are not generally used. The top and bottom edges may be blind stitched—that is, sewn with the first stitching we saw in upholstering a chair, but this is not always done. When many palliasses are made, a palliasse frame—that is, a box the exact size of the half palliasse internally, and serving the purpose of a templet, may be used. It conduces to rapid work, making individual measurements unnecessary.

Making Pillows and Bolsters. The usual size of pillow is 27 in. by 18 in., and in cutting the ticking for it the size of the two pieces is 28 in. by 19 in., the extra inch being the allowance for curvature. Feathers and down are the best materials; with the latter the covering is usually swansdown, the woolly side being left inwards. The amount of filling used depends upon the filling properties of the feathers selected for the work. Down requires only 1½ lb. for a pillow, and feathers run from 2½ lb. for white goose feathers to 3 lb. for poultry feathers.

The length of a bolster is decided by the width of the mattress, and the cloth required to go round the girth of the bolster is from 36 in. to 40 in. The bolster ends are either oval or oblong, with rounded corners. These ends, if oval, are cut about 11 in. by 7 in., the finished size of the oval being 10 in. by 6 in., the odd inch each way being taken up by the seam. The oblong ends are cut about 14 in. by 6 in., which are, of course, smaller when finished. The ends may be sewn to the body with a welt, the ends of the cylinder body being drawn into the welt for this purpose. The welting is not universal, however. The bolster takes rather more than twice as much stuffing as the pillow. Some bolsters are wedge shaped, tapering to the front. But this kind is found uncomfortable by most people; it is used more frequently in Continental countries than it is here.

Draperies and Hangings. In addition to the stuffing of furniture, the upholsterer is called upon to undertake the arrangement of curtains and hangings, and these may therefore be considered within the scope of upholstery. But success in this department cannot be obtained by precise instruction regarding procedure. It is a matter for the artistic eye rather than the skilled workman, and the best work can be done only by the possessor of an eye for grace of form, line, proportion, and colour. The ability to judge effect can be cultivated by careful study of the designs of the masters of the craft. But with the knowledge that instruction must be limited to the minor and mechanical part of the business, we can proceed to say what can be said with advantage.

The specific uses of hanging draperies are for window curtains, bed curtains, portières or door curtains, fireplace hangings, and curtains for pictures and mirrors. For window and door curtains the material should be heavy and pliable, so that the weight will give natural folds, and that the hang may not be made unnatural by any inherent stiffness in the material. Thus jute tapestries, Utrecht velvets, serges, and heavy printed crepes are suitable for such work. Window curtains should be cut to a length so that when hanging loose they will be about 3 in. longer than just sufficient to touch the floor. The hook from which the curtain chain is suspended should be from 4 ft. to 4 ft. 6 in. from the floor, and when the chain has been drawn up with the curtain within it, the bottom of the curtain will just about touch the floor. If there is to be a valance above the curtain, it may be cut straight or stepped, or with just enough of edge cutting to relieve the stiffness of absolute plainness. For a room of reasonable height, the valance is usually about 24 in. deep. If the material of a valance be tapestry, it should be panelled with plush or Utrecht velvet, the edges of the velvet being finished with gimp. The curtain should have a width of the same velvet right across its width, about a foot from the bottom.

Draping a Mantelshelf. The simplest form of household upholstering is the surround for a mantelpiece shelf. This may be made with side hangings; but the most elementary form is merely a valance along the front, and returned down each side. The shelf itself should be covered with cloth or baize, returned over the front edge and tacked to the under side. This cloth must be put on tightly, and with the weave of the cloth parallel to the line of the shelf. Wrinkles should be avoided; but if they appear, they may be dispelled by being damped and ironed. Now a strip of buckram may be tacked to the front edge, or to the front of the under side, and made to hang down in front and at the sides, but must not be so long that it will show under the valance. The valance looks best when of velvet or plush. The fringe of the valance, usually a ball fringe, must be sewn on before the valance is attached to the shelf, and the valance may be lined if desired. In fixing, tack it first in the centre, and then work along to the ends, making it tight, but not straining it, or the corners will not hang down square. The festoons are now put on. They must be of a material that is very soft, as any stiffness in these would ruin the appearance of the drapery. They must be uniform in size, and to make them so a pattern or templet, easily made out of card, may be used with advantage. A pinking iron, or mushing iron, as it is sometimes called, is a sort of steel chisel of crescent shape with a scalloped edge, and is used to shape the edges. It is used by placing its edge on top of the cloth on a block of lead and hammering it on to the cloth. It is possible to hang the festoons in one piece, drawing it up into festoons; but it is better to make individual festoons, tacking the upper edges to the shelf edge on top of the valance, and afterwards drawing the sides together and fixing them up with a tack. After this has been done, the points where the ends of the festoons join are fitted with rosetts, cords and tassels, or by fancy brass nails.

Wall Upholstery. A new class of work is falling to the lot of the upholsterer with a high-class trade. Silk, or other fabric, is stretched across walls from end to end, taking the place of wallpaper. The walls contain, or have fixed to them, battens all round, and first "bump"—a species of heavy cotton cloth—is stretched and nailed to the battens. Then the fabric, which has been sewn into one piece, is stretched over the bump and tacked. The work must be evenly done. Then gimp or braid is glued round the edge. The same treatment is applied to decorated skins, such as those for which the seventeenth century Spaniards were noted.

Carpet Laying. The planning and laying of carpets are operations which fall within the sphere of the upholsterer. A plan of the room is first made on paper, and great care is necessary to see that the sizes are correctly recorded, because to find that a carpet is a misfit after it has been sewn up is an expensive matter. When a room is of rectangular or square shape—and most rooms are—it is necessary to measure the distance between the opposite corners, and if the two diagonals are not of exactly the same length, it is obvious that the room is not truly rectangular or square, and the trouble must be found and noted, the carpet being made accordingly. When a wall recess or a window space is of circular form, a base line must be drawn from the two extremities, and parallel lines drawn every twelve or six inches from the base line to the arc, the size of each one of these parallel lines being recorded on the plan.

Plan of the Carpet. When cutting a carpet, the plan of the carpet—full size—should be drawn

upon the floor with chalk. The long, straight lines can best be made by a chalk line, that is, a length of cord which, in use, is rubbed with chalk, then held tightly at each end, lifted up in the middle and let go, when it makes a straight line upon the floor. Having made the plan of the carpet on the cutting floor, the border must first be cut. The corners of the border must be mitred. This is not difficult when the corner is square, because then each mitred end is half of a square, and the extreme points are cut to angles of 45°; but if the corner is not square, care and skill are necessary to secure a good and regular mitre. The carpet proper is now cut to fit the space within the border. Kidderminster carpets are 1 yd. wide, and other varieties are ¾ yd. wide. Difficulty may be found in matching the pattern at the seams where the lengths of carpet join, but it is imperative that this be done if the completed carpet is to be a symmetrical whole. The carpet is sewn either by hand or by machine. The selvedges of the carpet are sewn quite close to each other, and are, of course, sewn from the back. If the carpet has a plain woven selvedge, this is doubled back after sewing at the inner edge of the selvedge. If there is no such selvedge, each edge is turned in half an inch, so that, in planning and in cutting out, an inch has to be allowed in the width of each length for seaming. The ends of the various lengths must be doubled over and overstitched, so that they will not fray. Another method of treating the ends is to sew a piece of webbing across the end underneath, right up to the edge, and to overstitch the webbing and carpet together. The extra thickness is not appreciable from the upper side.

Stretching the Carpet. After the carpet has been sewn together, it should be stretched and have any wrinkles and creases taken out. The carpet-stretcher is used for this operation. This is an instrument with a handle resembling a broom handle, but the end is something like a flat shovel, with the point of the blade cut into prongs or teeth. By standing on the carpet and pushing it away with some force by means of the carpet-stretcher, the stretching is effected. Working from the centre, stretch it section by section until it fits the chalk plan made on the cutting floor. As one part is stretched, put drugget pins—that is, brass-headed studs—into it, so as to retain it in its stretched condition. Any loose or creased part may be made right by being damped by the application of a wet cloth and ironing.

The carpet may now be considered ready to be laid in its proper place. The floor upon which it is to be put should be smooth, all projecting nails and spikes should be withdrawn, and all projecting knots planed down. Felt may be put on before the carpet, thus thickening the floor covering. Care must be taken not to have the carpet and underlay so thick that doors opening inwards into the room will rub against the carpet. It may be necessary to unhinge and cut the door in such an event. The actual putting down of the carpet is a simple matter, the only precaution necessary being to make it quite straight.

Much trouble and time may be saved by using carpet squares instead of planning and sewing carpets. Carpet squares are rectangular carpets made in one piece, including the border. The room in such an event has a polished or stained floor around the carpet square.

Laying Stair Carpets. The laying of a carpet on a straight stair is a matter of extreme simplicity. It is simply tacked at the top or bottom, and put at each step under the stair rod and tacked at the other end. The stair-rod eyes should be screwed or driven in in a perfect straight line right from top to bottom of the stair, and their distance apart should be half an inch more than the width of the carpet, thus giving a quarter inch of clearance at each side. The distances at each side of the carpet between the wall and the balusters should be uniform. Stout pads or underfelt are usually put on each tread under the carpet: they give a softer tread, and prolong the life of the carpet. Stair pads should be about 1½ in. shorter than the carpet is wide, and, while stopping short of going right to the back of the tread, where they would interfere with the stair rod, they come down over the nosing or rounded front of the tread, where the greatest wear is. In America stair rods are practically unknown. Instead, stair carpets are tacked, or are held by stamped brass corners with short prongs, which are pressed into the angle made by the tread and the riser.

Carpets for Spiral Stairs. The laying of a carpet on a circular or spiral stair presents greater difficulties. If laid properly, it should look, when laid, as if it were unbroken from end to end. The best way, but the most expensive on account of the waste that it causes, is to cut the carpet across at the bottom of each riser, and to sew it together there. The more usual method is by folding triangular sections under the face at each riser, so as to absorb the unnecessary cloth caused by the circle. Whichever method be adopted, it is a good rule that the narrow carpet edge on every step should be some distance from the balusters. It will not be possible in some cases, where all the treads are not at the same angle.

Laying Linoleum. The practice of having linoleum made in bordered squares is lessening the need for fitting linoleum, although fitting is still the more common method. The standard width of body cloth, as the body of the linoleum is termed, is 2 yd. In cutting up there is room for skill in devising methods of saving waste. Patterns of geometrical design are more likely to be economically laid than floral carpet patterns, because the former can be reversed, and sometimes even turned sidewise, and still preserve the pattern, while the latter must be kept running one way.

The customary knife used for cutting linoleum and floorcloth is of the billhook variety, and must be kept sharp. Many workmen rub the knife edge through their hair every few minutes as they proceed, this perhaps imparting to the edge a lubricant that makes cutting easier. The chalk line is used for making straight lines. Some linoleums are uncertain, and may expand considerably after laying. The variety known as cork carpet is particularly liable to this defect. For this reason linoleum is sometimes not tacked into place for a week or more after it has been laid, so that if stretching takes place, sufficient may be cut off the edge to make a perfect fit. The edges of linoleum are tacked to the floor with thin brads, these being placed as close to the join as possible, and being put at the same spot on opposite sides of the join. Linoleum bordering is mitred in the same way as carpet bordering.

UPHOLSTERY *concluded; followed by* FIRE EXTINCTION

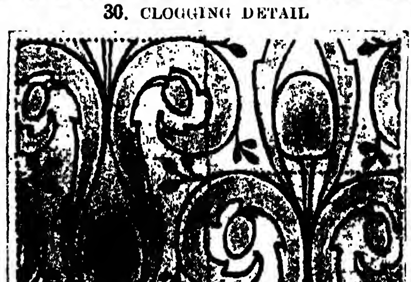
27. BLOCK PRINTING

28. MACHINE SURFACE PRINTING

29. MACHINE ENGRAVED PRINTING

30. CLOGGING DETAIL

31. A 14-INCH DROP PATTERN



32. DROP PATTERN FULL WIDTH OF PAPER

PRINTED PAPERS

PAPERS, FABRICS & STENCILS

Designing for Wallpapers and Printed Fabrics. Block and Machine Printing. "Sanitary" Papers. Stencilling. Designing, Cutting and Printing Stencils

Continued from page 6598

By H. NAPPER

THE covering of walls presents to the designer the largest field for the use of repeating pattern. There is very little technical difficulty to contend with compared with designing for carpets or woven fabrics.

Block-printing Wallpapers. This is the simplest and most artistic way of getting a repeated pattern. It is also the most expensive, not in the actual preparation, but in the time taken (by the printer) in producing the finished paper. It is necessary before starting the design to decide whether it is intended to use it for printing in transparent or solid colour—that is, whether the pattern is to be printed light on dark, or the reverse. Whichever is chosen, paint the design the way in which it will be printed—that is, do not paint in the ground if the pattern is to be printed, but paint solid the part that should represent the part of block which carries the colour on to the paper. The designer will then not be so likely to make dots or enclosed spaces, which would fill up when the block is placed on the colour pad and spread into a solid mass when applied to the paper [30].

The design, when bought, will be handed over to the block-cutter, who will trace and transfer the drawing on to a wooden block the size of the repeat—that is, if it is not larger than 21 in. by 24 in. (21 in. by 21 in. is the most convenient size). If the design be smaller than this, endeavour to repeat it twice in height, so that two repeats can be produced by the same impression. To draw designs for, say, 14 in. or 15 in. in height too large when doubled for the printer to handle conveniently, would mean a third more time and labour than in printing a piece of 12 yd. He will then, after colouring with a strong colour the shapes transferred to the block, cut away the ground, leaving the design raised. The same process will follow for every colour used, be it outline or mass. Small points will be left at the corners of the block, raised a little above the ornament, to enable the block to register and keep it firm on the printing table.

A Primitive Method. The blocks will be handed to the printer, who sits with a table in front of him, colour pad at the side. The block is then attached at the centre of the back to a lever, which is balanced so that he can easily place the block on the pad (which is coloured for every impression by his boy), and when charged with colour, place in the right position on the paper. With his foot pressed on a lever he brings sufficient weight down on the block to get a clear impression.

Only one colour is printed at a time. The paper, passing up to the ceiling on rods, is allowed to dry before other colours are added.

Two colours can be printed from one block if necessary by arranging, say, groups of flowers, so that they are well away from each other to allow different colours to be easily applied to the surface of block or on the colour-pad.

The effect of colour printed from the wooden surface is richer, fuller, and softer than when printed by machine. Especially is this the case when transparent colour is used; the texture or grain is very beautiful, and would not repeat itself in the next impression. Only the best quality of paper is suitable for block, owing to the lightness of handling compared with machine; it has not the tendency to destroy the surface or original texture.

Machine Printing. The method of printing by machine is entirely different from block. The design is traced and transferred to rollers, the circumference of which corresponds to the height of the repeat. An outline is then punched into the roller with strips of brass in varying thicknesses to give the variety of outline. The process is repeated with the rollers representing masses of colour, an outline first being made with brass, then filled in and felt added to the printing surface. It will be seen that this is a costly and difficult process—in some cases ten or twelve rollers are necessary. The rollers, when finished, are made to register—that is, to fit exactly into the proper place for printing. The method is much cheaper than block printing, for the machine produces miles of paper printed with the finished design.

The plain paper passes round a large drum, attached to which are the smaller rollers with the pattern; revolving against it, printing and at the same time re-charging with colour for the next repeat.

The whole pattern is, of course, wet, the rollers following so quickly that, although the rooms are heated, great care must be taken that too much of one colour does not fall upon another. Two colours that in block could be printed one over the other, must, in machine, be made to fit even so that a slight running together will result. Should a light outline be required, the filling-in colours must be about $\frac{1}{16}$ in. from it. There is not so much difficulty with a dark one, owing to the medium being thicker.

Engraved Rollers. This is the process commonly called "sanitary." This name was a great mistake from the artistic point of view, for it is capable of most beautiful results—in fact, almost anything can be represented in the matter of gradation and colour. The rollers are of copper, upon the surface of which the pattern is engraved by a series of punctured dots, giving, by their scarcity or density, the depth of colour required.

If two or more rollers are used, more than two or three different colours can be obtained. The colour being transparent, one can print over the other, and give various tones of the mixture.

Thus, blue roller printed over yellow would give a series of greens; blue over red, purples, etc. Care should be taken not to depend too much on the mixtures, for. owing to the great pressure of the rollers, the colour is liable to become muddy. The whole surface of the roller receives the colour, but before meeting the paper a scraper cleans the smooth parts and leaves the colour only in the punctured surface. Large surfaces of dark colour across the design should be avoided, as these parts would tend to wear away owing to the action of the scraper. The sizes of rollers vary both in surface and engraved printing. Those in ordinary use vary from 15 in. to 21 in. in circumference. In engraved work small patterns which repeat often in the width of 21 in. are engraved mechanically, saving tedious labour.

Hints for Wallpaper Design. In preparing designs for wallpapers use strong paper so that it will bear the rough handling of the cutter and printer. Use solid colour for block and machine, and keep the work on the hard side, leaving nothing to chance. This will enable the cutter to interpret the work better. For engraving use water-colour, but let the gradations have distinct tones so that the engraver can easily trace them.

In **27** and **28** there is given a small piece of a design showing the difference between a block and machine print. The outline of a block is inclined to spread and give a fat look, but with machine it is inclined to shrink and give a thin look, the speed of printing, of course, tending to give this effect. Part of the same design [**29**] for engraving shows the graduated effect with one roller.

Printed Fabrics. The printing of patterns on fabrics—velvets, cretonnes, silks, muslins, etc.—is in some way similar to the printing of papers. There are two distinct methods, block and machine. The same qualities of richness are produced by the hand block and the beauty of the original material is preserved to a far greater extent than in papers. It is impossible to produce by machine the velvety depth or flooding of colour which is the characteristic of block printing, owing to the material having to be of a smoother and harder nature so as to pass through the machine in an even manner. The breadth of rollers for machine is generally 30 in. for piece-goods (printed curtains run to much larger widths), but with block-printing a greater variety of widths can be used, thus making it of greater value for commercial purposes.

Block Fabric Printing. Block work is, of course, more expensive than machine owing to the time taken in printing and to the better material used, but its lasting powers are far greater, and for hangings nothing can be better. The material is generally pasted or strained on large tables, and the repeat set out as shown in illustration [**35**]. It will be seen that there is a different method of handling the blocks compared with paper printing. There is no way of reducing the weight of block, the entire weight being lifted by the printer and placed in position. This limits the size of the pattern, 10 in. by 15 or 18 in. to 15 in. by 15 in. being quite large enough for the printer to handle comfortably. If larger repeats are required, say 15 in. by 30 in., two sets of blocks must be used, thus doubling the cost of cutting and adding to the time of printing.

Varieties of Design for Block Printing. Care should be taken not to make the work too fine, and also as to the number of colours used; over-printing is sometimes an advantage, but should be used sparingly, as it tends to limit the range of schemes—the extra colours made are called "supers." If possible try to arrange the pattern so that it will look complete without the ground—that is, arranging for the principal part to be printed, say, in four colours, reserving two for extra effects. Use these to get darker effects by the addition of a pattern on ground which enables the manufacturer to produce two changes in appearance by the same design. Should the same blocks be used for velvet, requiring a dark ground, a still richer effect can be obtained by adding another block.

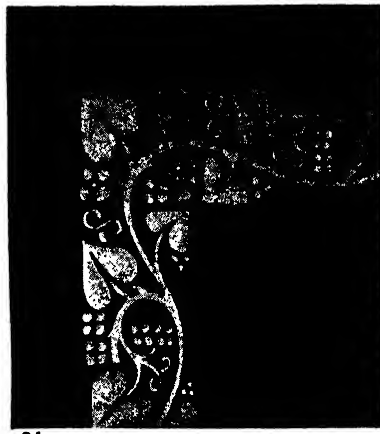
Another use made of block is in the printing of patterns for bed-spreads, table-covers, hangings, and other fabrics. in which a large surface of colour is required with borders, etc., in light colour [see illustration **34** to discharge or resist printing]. By the use of, say, two blocks, one for corner and the other for repeating patterns, an endless pattern can be made to work on any size material. The light part is left up on the blocks and is printed on to the raw material with chemicals which resist the action of colour. When printed the whole piece is dyed, leaving the pattern in the untouched ground colour of the material.

Machine Printing on Cretonne. The method used for this fabric is somewhat similar to the engraved process for wallpapers. The pattern is made on copper rollers, several tones of the same colour being obtained from each roller by means of lines or dots called "stippling." The illustration [**33**] suggests how the tones are worked by the engraver. It is not necessary to work the design in this manner. The exact shapes required can be painted in in water-colour, for although it will be made with dots and lines, the result will be a flat tone when printed, owing to the necessity of having always underneath a first roller to soften the material.

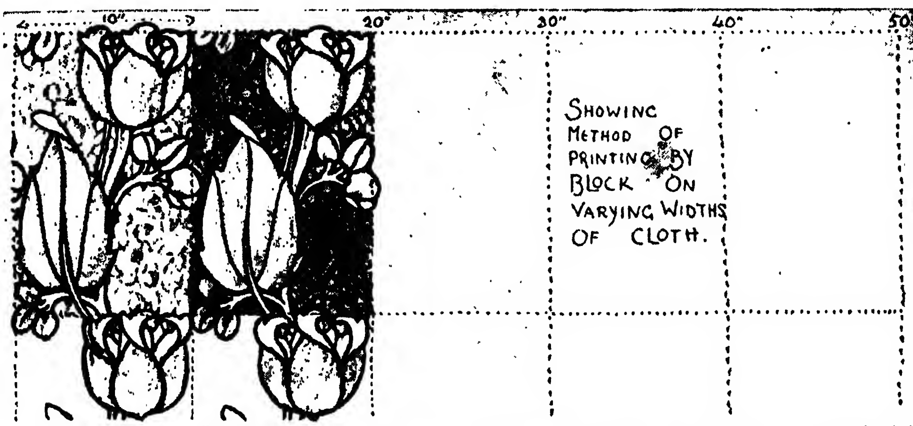
The design can be made to repeat in full width of rollers or any equal division, but the height or circumference of rollers in general use should be 15 in., unless otherwise stated. In making a design for ordinary or all-over patterns, the best method is to plan it on the diamond or lozenge, 30 in. by 15 in., to give greater freedom [**36**]. In 15 in. this becomes a drop, but for conventional work it is better to plan the drop in squares [**37**]. Reversible cretonnes are made by machine—that is, with a clear print on both sides of the material.

Stencilling. For the young designer, decorator, painter, or any other craftsman there are few crafts as interesting and instructive as

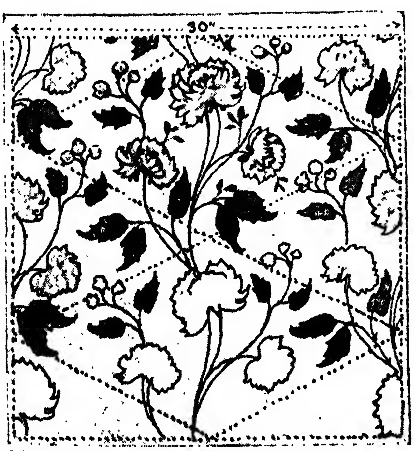
33. MACHINE PRINTING CRETONNE
Showing methods of stipple



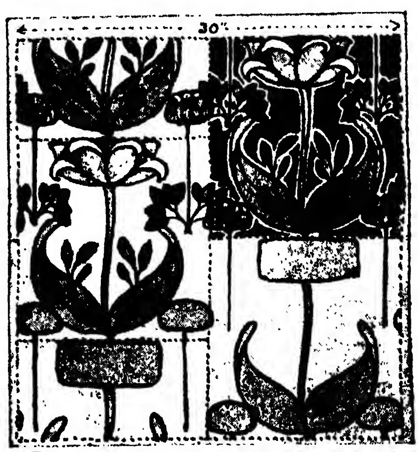
34. BLOCK PRINTING, DISCHARGE OR RESIST



35. SETTING OUT REPEAT



36. DESIGN IN DIAMOND STEP OR DROP



37. DESIGN IN SQUARE STEP OR DROP

PRINTED FABRICS

stencilling. In all the other branches of decorating by means of pattern, the designer, as a rule, has no control over its production; but with stencilling he can be designer, cutter, and printer. The production of the plates is so simple and inexpensive that the decoration can be planned and completed in the room or house in which it is required. Take the stencilling of a frieze [40] as an example. The interesting or the largest part of the design can be arranged in the centre of the wall, and the motive altered in colour or simplified in design, so that when the corners are reached, the effect of overcrowding can be saved, and the decoration given the appearance of having been produced specially for the room [38]. The same plates can sometimes be used for door panels or screens, giving quite a different effect. It is quite easy to stencil on almost every kind of plain fabric, such as muslin, arras cloth, linen, or velvet.

Designing for Stencilling. As an example of preparing a design for use in pure stencilling a frieze may be taken which is to be worked with three plates. By a little arrangement one or both of these plates can be made to give two distinct colours. The best method is to decide on some simple arrangement and plan out roughly the masses of colour without much thought regarding the drawing. Keep them as large as possible so that there is plenty of scope for graduating the colour, the great charm of stencilling being the accidental effects.

For the first plate, flower and leaf can be arranged together, reserving the second and third plates for the background [39]. Now take a solid white, and begin to give the shape you require to the flower, etc., by painting an outline on the masses of colour. This serves two purposes, giving shape to the pattern and strength to the plate. Break up the mass as little as possible, and see that the full amount of expression is obtained for every line. These lines are called ties. Do not be afraid of them or paint them out afterwards, for this is a sign of the incompetent craftsman. Treat the background plates in the same way, but give them an entirely different effect, either giving a lot of even detail or making them almost plain.

Cutting the Plates for Stencilling. Take a piece of tracing-paper (fairly strong, for it must stand a good deal of rubbing), and make a careful tracing, outlining each side of the ties. This is very essential in order to save the trouble of thinking of the part to be cut. Then take four pieces of cartridge paper (thick), being certain that they are much larger than the design. In one of them put two drawing-pins, point up, at top and bottom of paper—this is for the registration of plates to ensure their fitting exactly—then place the other piece on the top and press the pins through. Do the same with the tracing, and it will save much unnecessary trouble. Now rub the tracing on to the three plates, taking care that the tracing is exactly in the same holes. Start by cutting the flower-and-leaf stencil-plate first. In doing so, place the paper on a piece of thick glass, and with an ordinary knife cut out the parts enclosed by a line. Care should be taken to cut away from the corners in every case, so that slipping across the ties is avoided [42].

When the cutting of the first stencil is complete, lay it on to the background plate, and stencil through the cut parts to verify its fitting exactly; proceed with the second plate in the same way. Afterwards give the plates a coat of knotting or varnish on both sides, and allow them to dry thoroughly.

Practical Stencilling. Almost any medium can be used in stencilling—water-colour, oil, tempera, etc. For small work water-colour is the best. When once the difficulty of preventing the colour from running too freely from the brush has been mastered, always use large brushes [41], even for the finest work: they cover the ground more quickly, and give the colour a better texture. Never by any chance allow the brush to go directly into the colour. Mix the colour rather thick, place it in a saucer, on the top of which put a piece of clean flannel, and charge the brush by rubbing it on the top of the flannel. By this means the colour will be taken up evenly, and too much moisture, which would have the tendency of running underneath the ties, will be prevented. Cut on the plates a small piece more than is required [see petal of flower in 39A], so that if the design runs along it can be seen at once whether it fits into the right place.

BOOKS ON DESIGN

DESIGN.—"The Anatomy of Pattern," "The Distribution of Ornamental Design," "The Planning of Ornament," and "The Application of Ornament," by L. F. Day (Batsford); "Studies in Design," by C. Dresser (Cassell); "Lessons in Decorative Design," by F. G. Jackson (Chapman); "The Bases of Design," and "Line and Forms," by W. Crane (Bell).

ILLUMINATION.—"Primer of the Art of Illumination," by F. W. Delamotte (Lockwood); "Lessons in the Art of Illuminating," by Rev. W. J. Loftie (Blackie); "Writing, Illuminating and Lettering," by E. Johnston (Hogg); "Manual of Illumination," by Laing (Winsor & Newton).

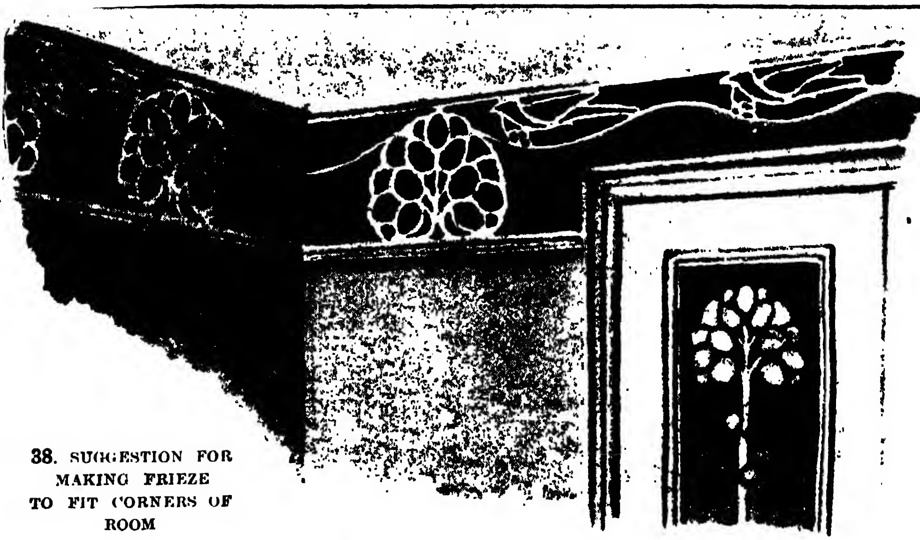
PRESS ILLUSTRATION.—"Pen Drawing and Pen Illustration," by Pennell (Macmillan—out of print); "Guides to Art Illustration," by J. S. Hodson (Low); "How to Draw in Pen and Ink," by H. Furniss (Chapman); "Modern Illustration," by Pennell (Bell); "Pen and Ink Drawing," by Robertson (Winsor & Newton).

STENCILLING.—"Practical Stencil Work," by F. Scott Mitchell (Trades Papers Publishing Co.).

TEXTILES AND WOVEN FABRIC DESIGN.—"Design in Textile Fabrics," by T. R. Ashenhurst (Cassell); "Textile Fabrics," by D. Rock (Chapman); "Embroidery and Tapestry Weaving," by A. H. Christie (Hogg).

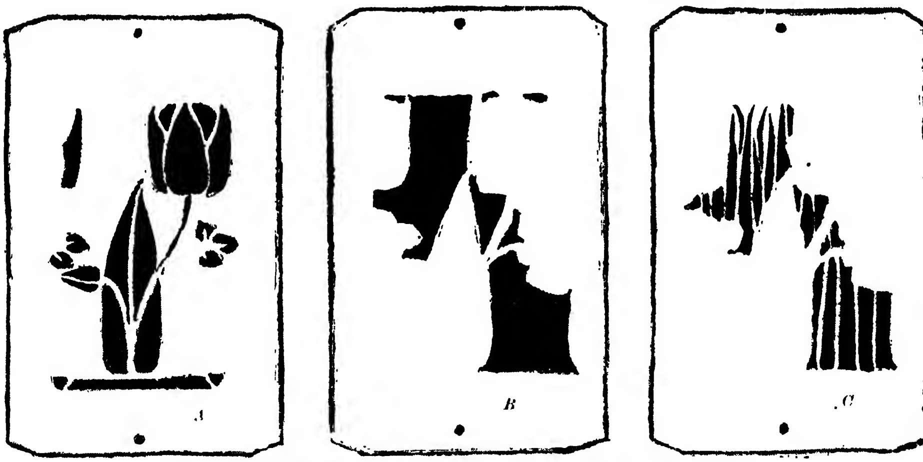
WALLPAPERS.—"Practical Design: A Handbook on the Preparation of Working Drawings for Carpets, Woven Fabrics, Wallpapers," etc., by White Gleeson (Bell).

DESIGN *concluded*

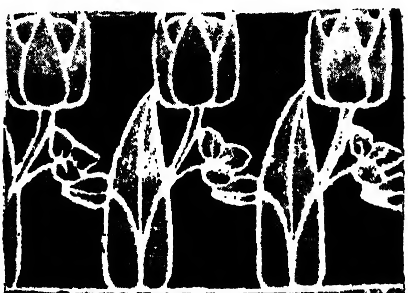


38. SUGGESTION FOR MAKING FRIEZE TO FIT CORNERS OF ROOM

Tree-top used in door panel



39. STENCIL-PLATES *A*. Flower and leaf. *B* and *C*. Background



40. FRIEZE STENCILLED WITH PLATES A, B, AND C

41. STENCIL-BRUSH

42. CUTTING FROM CORNERS AND DOUBLE OUTLINE

STENCILLING

THE WORLD'S MINERALS

A List of the Important Minerals and Mineralogical Synonyms, Giving Their Chemical Composition, Physical Properties, Products, Uses, and Other Particulars

By S. G. STUBBS

THE purpose of this article is to give in convenient form a comprehensive account of the characters and uses (if any) of all the important minerals. The 1,300 names and synonyms given in the pages following are not equal to more than one-third of the minerals dealt with in Dana's wonderful "System of Mineralogy," but the two-thirds here omitted are not important economically or mineralogically. Rocks are not dealt with here. They are mixtures of simple minerals, and particulars of them will be found in other pages or in any good work on petrology or petrography.

Important synonyms of the minerals dealt with are included in the tables and are indicated by the italic *s* (synonym); for particulars of these, reference is to be made to the name given. Where a mineral is a more or less closely related variety of a more important mineral, this fact is noted, the italic *v* (variety) being used.

In the second column the chemical formula or chemical composition is indicated by means of the ordinary symbols and formulæ of chemistry, which are fully explained in the course on CHEMISTRY. Where possible the structural formulæ are given. Where it is not possible to assign a definite formula the constituent compounds or elements are given. Elements enclosed in brackets and separated by commas can, and do, replace one another without altering the crystalline form of the mineral.

Physical Properties. All minerals vary greatly in colour, generally on account of accidental impurities derived from the rock or other environment in which they occur, and the colours given here are those which are most usual. In the fourth column are stated the approximate specific gravities of the minerals. Where the limits are somewhat wide they are noted. For methods of determining gravities of minerals see Precious Stones, page 5853; much of the information appearing there as to the physical properties of stones applies equally to other minerals.

The figures denoting the hardness of the minerals are those of Mohs' scale, which comprises ten degrees of hardness, the following being the typical minerals:

1. Talc	6. Felspar
2. Rock salt, or gypsum	7. Rock crystal (quartz)
3. Calcite	8. Topaz
4. Fluorspar	9. Corundum
5. Apatite, or glass	10. Diamond

This scale is entirely arbitrary, and the value of the degrees varies greatly, the difference between 10 and 9, for instance, is much greater than that between 9 and 8 [see also page 5852].

Crystalline Systems. The system of crystallisation to which the mineral belongs is indicated by the Roman numeral in the sixth column. The six systems are:

I. Isometric (Cubic, or Regular);
II. Tetragonal (Pyramidal);
III. Hexagonal (Rhombohedral);
IV. Orthorhombic (Rhombic, Trimetric);
V. Monoclinic (Monosymmetric, Oblique);
VI. Triclinic (Asymmetric, Anorthic).

Although crystals occur in very many geometrical forms, it was early seen that many of these were merely modifications of simpler forms, and ultimately, as the result of the birth and decease of many ingenious theories, it was shown that all these modifications might be referred to the six simple systems given above, and, moreover, that, as the result of the mathematical laws of symmetry, no more than six simple systems are possible.

The Principles of Crystal Systems. These systems are based on the relations of the axes of the crystals—imaginary lines connecting opposite points, such as opposite corners or the centres of opposite faces. In the first system, the Isometric, or Cubic, the axes are all equal, and cut one another at right angles. This is the simplest and most regular system, and examples of it are common salt and fluorspar, which crystallise in the form of a cube. In the Tetragonal system only two of the axes are equal, but all intersect at right angles. The precious stone zircon is an illustration of this system. Other systems are considered to have only three axes, but the Hexagonal, or Rhombohedral, has three axes intersecting at 60°, and a fourth cutting these at right angles. In the Orthorhombic or Rhombic system none of the axes are equal though they cut one another at right angles. The majority of minerals fall into this class, of which barytes and topaz are representatives. Monoclinic or Monosymmetric minerals have all their axes unequal and only two of the axes intersecting at right angles. Quartz takes this form. The sixth system, the Triclinic, or Anorthic, is, as its second name indicates, entirely irregular. None of the axes are equal and none intersect at right angles.

Abbreviations Used in the Tables. Some minerals are not found crystalline. These are indicated by the abbreviations Am., Amorphous; Mc., Micro-crystalline; Mass., Massive. In the seventh column are a set of abbreviations indicating the appearances of the minerals. These are:

A	Adamant	S	Silky
B	Brilliant	Sa	Sub-adamant
D	Dull	Sm	Sub-metallic
E	Earthy	Sp	Splendent
F	Fibrous	Sv	Sub-vitreous
G	Greasy	Tc	Translucent
Gl	Glinting	Tp	Transparent
O	Opaque	U	Unctuous
M	Metallic	V	Vitreous
P	Pearly	W	Waxy
R	Resinous		

In the eighth column are given very briefly the products, uses, or other particulars of the minerals. The products are given first, and are followed either by the uses or other particulars.

For a chemical classification of the minerals and for a short account of the principles of mineralogy and crystallography reference should be made to the course on GEOLOGY, page 765.

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
ABICHITE, *s.* Clinoclase							
Abrazite, *s.* Gismondite							
Acanthite	AgS	Iron-black	7·33	2·5	IV.	M.	Similar to Argentite
Acerdèse, *s.* Manganite							
Achirite, *s.* Dioptase ..							
Achmatite, *s.* Epidote..							
Achrematite	$Pb_3As_2O_8$ and Pb_2MoO_5	Yellow to red	5·9	3–4	II.	—	Found in Mexico
Achroite	Very complex silicate	Colourless	3·0	7–7½	III.	V.	A tourmaline *See* p. 5856
Achtaragdite	$SiO_2,MgO,$ Fe_2O_3,Al_2O_3	Ash-grey	2·32	2–2·5	I.	—	A pseudomorph
Aciculite, *s.* Aikinite							
Acmite	$NaFe(SiO_3)_2$	Brown or black	3·5	6	V.	O.	Mn or Ti may be [present
Actinolite (Hornblende group)	(Ca,MgO, FeO)Si	Green to black	—	—	IV.	Tc.	Found in Scotland, Sweden, North America
Adamantine spar, *s.* Corundum	—	Hair-brown					
Adamite, Adamine	(ZnOH) $ZnAsO_4$	Honey-yellow to violet	4·34	3·5	IV.	Tp.	Vitreous lustre; ZnO (56 per cent.)
Adularia, *v.* Orthoclase ..	Al,K,Na,Si_3O_8	Almost colourless	2·53	6	V.	Tp. Tc.	If blue opalescent, called Moonstone
Ædelforsite	—	—	—	—	—	—	Impure Wollastonite
Ægirite, Ægyrite	$NaFe(SiO_3)_2$	Greenish black	3·5	5·5	V.	O.	Mn and Mg may be present
Ænigmatite	$(Si,Ti)O_2,$ FeO,Na_2O	Black	3·8	5·5	VI.	O.	Essentially a titano-silicate; very rare
Ærosite, *s.* Pyrargyrite							
Æschynite	Ni,Ta,Ti, Ce,Th, and La	Iron-black	4·9	5·0	IV.	O.	
Agalmatolite (Figure Stone) ..	$AlKH,Si_2O_6$	Various	2·8	2–3	IV.	Tc.	Carved by Chinese
Agaric mineral, Rock milk ..	$CaCO_3$	White	2·7	—	III.	—	Very soft; deposited in caverns
Agate, *v.* Quartz	SiO_2	Variegated	2·65	7	III.	—	Banded chalcedonies. *See* pp. 767, 5852
Agate jasper, *v.* Quartz ..	SiO_2	Variegated	2·65	7	III.	—	Is jasper with chalcedony veinings
Aglaite	$SiO_2Al_2O_3$	—	3·13	6·5–7	V.	V.	A variety of Spodumene
Agnesite, Bismuthite	$Bi_2O_3.CO_2$	White, green	6·9	4–4·5	Am.	E.	
Agricolite	$Bi_4(SiO_4)_3$	Colourless to yellow	6	5	I.	A.	
Aguilarite	$(Ag_2)_2SeS$	Iron-black	7·59	2·5	I.	M.	
Aikinite (Needle-ore)	$(PbBiCuS_3)_2$	Blackish-grey	6·7	2·5	IV.	M.	Bismuth
Ainalite, *v.* Cassiterite ..	SnO_2	—	6·9	6·7	II.	M.	Tin
Aithalite, *s.* Asbolite							
Akontite, *s.* Glaucodote							
Alabandite, Alabandine ..	MnS	Iron-black to grey	4	3·5	I.	O.	Manganese; found [S. America
Alabaster, *v.* Gypsum	$CaSO_4,2H_2O$	Colourless, white and various	2·2	1·5–2	V.	Tp.	Ornamental carving, pp. 1169, 1721
Alalite, *v.* Diopside	$CaO.MgO.SiO_2$	Greyish white	3–3·5	5·6	V.	Tp.	Augite derivative
Alaskaite	$(Pb,Ag)S.Bi_2S_3$	Grey	6·8	3–4	—	M.	
Albertite, *v.* Coal	C,H,N, and O	Velvet-black	—	—	—	A.	Found Nova Scotia; [gas-making
Albine, *v.* Apophyllite.. ..	$CaCO_3(HK)SiO_2$	White	2·3	4·5	II.	O.	
Albite (Felspar group).. ..	$Al(Na,K)Si_3O_8$ Si_3O_2	Colourless	2·6	6	VI.	V.	Fine-pottery manufacture, p. 768
Alexandrite, *v.* Chrysoberyl ..	$BeAl_2O_4$	Emerald green	3·68	8·5	IV.	Tc.	Precious stone, pp. 5853, 5855
Algerite..	$KAl(SiO_3)CaCO_3$	Yellowish	2·7	3	II.	Tp.	Altered Scapolite
Allactite	$Mn_7(OH)_8(AsO_4)_2$	Brownish red	3·84	4·5	V.	V.	Manganese
Allanite..	$R_3Si_2O_3.R_2SiO_5$	Black	3·4	6	V.	V.	R may be Al, Fe, Ce, La, Yt
Allemontite	$SbAs_3$	Various	6	3·5	III.	M.	Antimony and arsenic
Allophane	$Al_2SiO_5.5H_2O$	Various	1·8	3	Am.	V.	
Alluaudite	MnO,P_2O_5 Fe_2O_3	Brown	3·4	4–5	IV.		Is altered Triplite carbuncle
Almandine (Precious Garnet)	$Al_2Fe_3(SiO_4)_3$	Red	3·9–4·2	7	I.	Tp.	Precious stone as
Almandite (Common Garnet)	$Al_2Fe_3(SiO_4)_3$	Reddish-brown	3·9–4·2	7	I.	Tc.	Sand or garnet-paper
Alstonite, Bromlite	$(Ca,Ba)CO_3$	White	3·7	4	IV.	V.	Found with Witherite
Altaite..	PbTe	Tin-white	8·1	3·25	I.	B.	A telluride
Alum, *s.* Kalinite	$KAl(SO_4)_2 12H_2O$	White	1·75	2	I.	V.	*See* index; *also* Mendozite, *intra*
Aluminite	$Al_2O_3.SO_3.9H_2O$	White	2·6	1	V.	D.	Found in clay beds
Alunite, Alumstone	$K(AlO)_3(SO_4)_2 \cdot 3H_2O$	Various	2·6	4	IV.	V.	Fine-alum preparation
Alunogen, *s.* Keramohalite ..	$Al_2(SO_4)_3.18H_2O$	White	1·7	2	V.	S.	
Alurgite (Mica group) ..	Contains Mn	Purple	2.9	2–3	—	P.	
Amalgam, Native	Ag,Hg	White	10·5–14	3	I.	M.	Silver
Amazon stone, *v.* Microcline..	$(K,Na)Al_2Si_3O_8$	Green	2·55	6·25	VI.	V.	
Amber	$C_{40}H_{64}O_4$	Yellow, brown	1	2·5	Am.	W.	Is a fossil resin [See index
Amblygonite	$(AlF)LiPO_4$	White to green	3·1	5·5	VI.	V.	
Ambrite, *s.* Retinite	C,H,O	Yellowish-grey	1·03	2	Am.	G.	Resembles Kauri [gum
Amesite, *v.* Clinochlore ..	$H_4(Mg,Fe)_2$ Al_2SiO_9	Apple-green	2·7	2·5–3	—	P.	Occurs with Diaspore
Amethyst, *v.* Quartz	SiO_2	Purple, yellow	2·6	7	III.	S.	Precious stone
Amianthus, *s.* Asbestos ..	$(Ca,Mg,Fe)SiO_3$	White	3·2	5·5	V.	F.	Variety of Serpentine

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Amphibole *s.* Hornblende	$(Mg.Fe_3Ca(SiO_3)_4$	Blackish	3·1	5·5	V.	V.	Many compounds; chief asbestos
Amphigene, *s.* Leucite							
Analcite, Analcime	$AlNa(SiO_3)_2.H_2O$	White, red	2·2	5·5	I.	V.	
Anatase	TiO_2	Various	3·9	6	II.	A.	Titanium
Andalusite	Al_2SiO_5	Whitish, reddish	3·1	7	IV.	V.	Very strongly dichroic
Andesine (Felspar group)	$AlNaSi_2.SiO_8$	Various	2·68	5·5	VI.	V.	Related to Albine and Anorthite
Andesite, *s.* Andesine							
Andradite (Garnet group)	$Fe_2Ca_3(SiO_4)_3$	Various	3·8	7	I.	—	Common garnets
Anglesite	$PbSO_4$	White	6·2	3	IV.	A.	Lead (68 per cent.), p. 5985
Anhydrite	$CaSO_4$	White, reddish	2·9	3	IV.	V.	An anhydrous gypsum
Animikite, *v.* Dyscrasite	Ag_9Sb_2	White	9·45	3·5–4	IV.	—	In arsenical silver ores
Ankerite	$(Ca,Mg,Fe,Mn)CO_3$	Grey, white	3	4	III.	V.	Dolomitic
Annabergite	$Ni_3(AsO_4)_2.8H_2O$	Apple-green	3	2·23	V.	Gl.	Nickel
Anomite, *v.* Biotite							
Anorthite (Felspar group)	$AlCaSi_2AlO_8$	White, grey, red	2·76	6	VI.	V.	*See* p. 768
Anthophyllite, Antholite	Mg,Fe,SiO_3	Greyish	3·15	5·3	IV.	V.	
Anthracite	C; H, O, etc.	Black	1·7	2·75	Am.	Sm.	Hard, smokeless coal
Antillite	SiO_2,MgO,FeO	Greenish-brown	2·52	3·5–4	—	—	Similar to serpentine
Antimonite, *s.* Stibnite							
Antimony glance, *s.* Stibnite							
Antimony	Sb	Tin-white	6·6	3	III.	—	Rarely crystalline
Apatite	$3Ca_3P_2O_8,CaF_2$	All colours	3·1	5	III.	V.	Phosphoric acid, phosphorus; manure
Aphanesite, *s.* Clinoclase							
Aphrodite	$MgSiO_3,H_2O$	White	3·2	2	—	O.	Resembles Sepiolite
Aphrosiderite	Fe,Al,SiO_5,H_2O	Olive-green	2·8	2–2·5	—	Tp.	Chlorite group
Aphthitalite	$(K,Na_2)SO_4$	White	2·63	3–3·5	III.	V.	
Apjohnite	$MnSO_4.(Al_2SO_4)_3$	White	1·7	1·5	V.	S.	From S. Africa [*See* p. 5855
Apophyllite	Ca_4,K,SiO_3,H_2O	White, yellowish	2·3	5	II.	P.	
Aquamarine *v.* Beryl	$Al_2Be_3(SiO_3)_6$	Green, bluish	2–7	7·5	III.	Tp.	Precious stone
Aragonite	$CaCO_3$	White, grey, etc.	2·9	4	IV.	S.	Resembles Calcite
Arcanite, *s.* Aphthitalite							
Ardennite	$Mn_4,Al_4,VSiO_5$	Yellow	3·6	6–7	IV.	—	Vanadium
Arfvedsonite (Horn-blende group)	Fe,Mg,Na_2Ca,SiO_3	Black	3·4	6	V.	V.	
Argentite (Silver-blende)	Ag_2S	Lead-grey	7·2	2·5	I	—	Important silver ore
Argyrodite	$(Ag_2S)_3.GeS_2$	Greyish-black	6	2·5	V.	—	Germanium
Arkansite *v.* Brookite	TiO_2	Red, brown, etc.	4·2	5·5	IV.	A.	Titanium; from Arkansas
Arksutite, *s.* Chiolite							
Arnimite *v.* Herrengrundite	CuO,SO_3,H_2O	Green	3·1	2·5	V.	—	From Plauitz
Arquerite *v.* Amalgam	$Ag_{12}Hg$	White	10·8	3	I.	M.	From Chili and Brit. Columbia
Arsenic	As	Grey	5·7	3·5	III.	M.	For uses see index
Arseniosiderite *s.* Löllingite							
Arsenolite	As_2O_3	White	3·7	3	I.	A.	Commercial "white arsenic"
Arsenopyrite, *s.* Mispickel	$FeAsS$	Greyish-black	6	5·5	IV.	M.	Arsenic (46 per cent.)
Asbestos (Hornblende group)	$(CaMgFe)SiO_3$	White to brown	3·2	5·5	V.	F.	*See* Chrysolite
Asbolite, Asbolan, *v.* Wad	$Co(Fe,Cu)O$	Bluish-black	3·5	2·25	Am.	R.	Cobalt
Asmanite	SiO_2	Colourless	2·3	7	IV.	V.	
Asparagus-stone, *s.* Apatite							
Aspasiolite	Si,Al,Fe,Mg oxides	Greyish	2·7	7	—	—	A pseudomorph of Iolite
Asphaltum	$C_{14}H_{18}O$	Black to brown	1·5	1·25–2	Amor.	R.	Paving, covering, etc.
Astrakanite, *s.* Blödite							
Astrophyllite	$R,R_2Ti(SO_4)_4$	Yellow to gold	3·3	3	IV.	P.	R is H, Na, K; R_2, Fe, Mn, Ca, Zr
Atacamite	$Cu_2ClH_3O_3$	Emerald green	4·1	3·5	IV.	V.	Copper (59 per cent.)
Atelestite	$H_2Bi_3AsO_8$	Yellow	6·4	3–4·5	V.	Te.	
Atopite	$Ca_2Sb_2O_7$	Yellow	5·0	5·5–6	I.	G.	
Augite (Augite group)	$AlO_3.MgAlSiO_3$	Greyish	3·3	6	V.	V.	Resembles hornblende, pp. 768, 1009
Aurichalcite	$(Zn,Cu)(OH)_2CO_3$	Greenish-blue	3·7	2	V.	S.	
Autunite, Calcouranite	$(UO_2)_2Ca(PO_4)_2.8H_2O$	Citron yellow	3·1	2	IV.	P.	Uranium
Avanturine felspar, *v.* Oligoclase	Al_3,Na,Ca,Si_5O_{16}	Greyish-white	2·56	6	VI.	V.	In jewellery as Sunstone
Axinite	$H_2Ca,Fe,Mn,BO,(SiO_4)_5$	Brown, grey	3·3	7	VI.	V.	
Azurite, Chessylite	$(CuOH)_2Cu(CO_3)_2$	Blue	3·7	3·75	V.	P., V.	Copper, p. 4127
BABINGTONITE	$(Ca,Fl,Mn)SiO_3$	Greenish-black	3·36	5·5	VI.	Sp.	Cornish iron ore
Baltimorite, *s.* Serpentine							
Barcenite	Sb,S,Hg,Ca,H_2O	Dark grey	5·3	5·5	—	D.	
Barsowite, *v.* Anorthite	$CaAl_2.Si_2O_8$	White	2·58	5·5–6	IV or V	P.	Corundum gangue
Barylite	$Ba_4Al_4Si_7O_{24}$	Colourless	4·03	7	—	G.	
Barytes (Heavy-spar)	$BaSO_4$	Varies	4·3	3	IV.	V.	White-lead substitute; pigments; paper-making
Barytocalcite	$(Ca,Ba)CO_3$	White, yellow	3·6	4	V.	V.	

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Basaltic hornblende	$(Mg,Fe)_2,Al_2O_3,SiO_3$	Black	3·1	5·5	V.	—	
Basanite, *s.* Lydian stone							
Bastnäsite	$[(Ce,La,Di)F]CO_3$	Yellowish-grey	4·9	4·5	III.(?)	V.	Ce, La, Di; from emerald mines
Bauxite	$Al_2O_3.2H_2O$	Whitish, etc.	2·5	3(?)	Oolitic	E.	Aluminium: alum mfr.; fire-bricks, crucibles
Beauxite, *s.* Bauxite							
Beegerite	$Pb_6Bi_2S_9$	Grey	7·2	—	I.	M.	
Bell-metal ore, *s.* Stannite							
Bernstein, *s.* Amber ..							
Berthierite	$FeSb_2S_4$	Greyish-black	4·1	3	Pr.	M.	
Bertrandite	$4BeO.2SiO_2.H_2O$	Colourless	2·6	6·5	IV.	V.	
Beryl (Emerald)	$Al_2Be_3(SiO_3)_6$	Green, blue, etc.	2·7	7·5	III.	V.	Flawless, as precious stone. *See* p. 5855
Beryllonite	$BeNaPO_4$	Colourless	2·84	5·75	IV.	V.	From U.S.; precious stone
Berzeliite, Kühnite, Pyrrharsenite	$(Ca,Mg,Mn,Na_2)_3(AsO_4)_3$	White to yellow	4·0	5	I.	R.	
Berzelite, *s.* Mendipite ..	$Pb_3O_2Cl_2$	White to yellow	7·1	3	IV.	A.	
Bieberite	$CoSO_4.7H_2O$	Rose-red	1·9	2·5	V.	S.	An efflorescence
Biharite *s.* Agalmatolite							
Bindheimite	$Pb_3Sb_2O_8.4H_2O$	White, grey, etc.	4·7	4	Am.	R.	Cu often replaced by Ag to 14 per cent.
Binnite, *s.* Tennantite	$Cu_6As_4S_9$	Dark grey	4·47	2·75	I.	M.	
Biotite	$(Mg_{12},Fe)_2(K_3,H)_2(Al_7,Fe)_2(SiO_4)_3$	Black, brown	2·9	2·5	V.	P.	Stained with FeO; commercial mica; electrical apparatus
Bismite (Bismuth ochre)	Bi_2O_3	Greenish-yellow	4·3	–	IV.	A.	Naturally non-crystalline
Bismuth	Bi	Silver-white	9·7	2·25	III.	M.	Alloying metal
Bismuth blende, *s.* Eulytite							
Bismuth glance, *s.* Bismuthite							
Bismuthinite	Bi_2S_3	Steel-grey	6·4	2·5	IV.	M.	Bismuth ore
Bismuthite	$Bi_2O_3.CO_2.H_2O$	Grey, yellow, green	6·9	4	Am.	D.Gl.	Bismuth ore
Bismutosphærite	Bi_2CO_5	Yellow to grey	7·3	3-3·5	Sph.	—	Fibrous structure
Bitterspar, *s.* Dolomite							
Bitumen, *s.* Asphaltum							
Black copper, *s.* Melaconite							
Black-jack, *s.* Blende							
Blende	ZnS	Yellow, red, green	4	4	I.	A.	Most important zinc ore, 60 per cent.
Blödite	$MgSO_4.Na_2SO_4$	Colourless	2·2	2·5	V.	V.	
Bloodstone, *v.* Quartz ..	SiO_2 and FeO	Green	2·7	7	Mc.	—	Has blood-like spots of red
Blue-stone, Blue vitriol, *s.* Chalcanthite							
Boart, imperfectly crystallised *v.* Diamond		Black	–	10	I.	—	Diamond-cutting powder
Bog iron ore, impure *v.* Limonite	Fe_2O_3,H_2O	Brown to yellow			Am.		Contains organic substances; foundry pig iron
Bog-manganese, *s.* Wad							
Bole	$Al_2H_4Si_2O_9.Aq.$	White, yellow, red	2·5	2	Am.	R.	Gold-leaf adhesive
Boltonite, *v.* Forsterite ..	Mg_2SiO_4	Red	3·2	6·7	IV.	V.	
Bone-turquoise, *s.* Odontolite							
Boracite	$Mg_7Cl_2B_{16}O_{30}$	White-grey	3	7	I., IV.	V.	
Borax	$Na_2B_4O_7.10H_2O$	White, part grey	1·7	2·25	V.	R.	General flux; in medicine
Bornine, Bornite, *s.* Erubescite *and* Tetradymite							
Borocalcite, *s.* Ulexite							
Bostonite, *s.* Chrysotile							
Botryogen	$MgO.FeO.Fe_2O_3.4SO_3$	Hyacinth red	2·04	2-2·5	V.	V.	
Botryolite, *s.* Datolite							
Boulangerite	$Pb_3Sb_2S_6$	Lead-grey	5·6	2·75	IV.	M.	
Bournonite	$Pb_2Cu_2Sb_2S_6$	Grey to black	5·8	2·75	IV.	M.	Old Cornish copper ore
Boussingaultite	$(NH_4)_2SO_4.MgSO_4$	White	1·68	—	V.	—	
Bowenite, *v.* Serpentine ..	$(MgFe)_3H_4Si_2O_9$	White	2·6	5·5–6	IV.	V.	
Bragite, *s.* Fergusonite							
Brandtite	$Ca_2MnAs_2O_8.2H_2O$	Colourless to white	3·6	5-5·5	VI.	V.	
Braunite	Mn_2O_3	Black	4·7	6·25	II.	M.	Manganese (63 per cent.)
Bredbergite, *v.* Andradite ..	$Fe_2Mg,Ca_3(SiO_4)_3$	—	3·74	7	I.	V.	A common garnet
Breithauptite, *v.* Niccolite ..	NiSb	Copper-red	7·5	5·5	III.	M.	Nickel ore
Breunnerite	$(Mg:Fe)CO_3$	Yellowish-white	4	4	III.	V.	
Brewsterite	$H_4(Sr,Ba.Ca)Al_2(SiO_3)_6$	White	2·45	5	V.	V.	
Brittle silver, *s.* Stephanite							
Brochantite	$(CuOH)_4SO_4$	Emerald green	3·8	3·5	IV.	V.	
Bromargyrite	AgBr	Bright yellow	5·9	2·3	I.	A.	Chilian silver ore 57 per cent.
Bromlite	$(Ca,Ba)CO_3$	White	3·7	4	IV.	V.	
Bromyrite, *s.* Bromargyrite							
Bronzit, *s.* Enstatite							
Bronzite, *s.* Seybertite							
Brookite	TiO_2	Brown to black	3·8	5·5-6	IV.	A.	Titanium
Brown Hæmatite, *s.* Limonite							
Brucite	$Mg(OH)_2$	White	2·3	2	III.	P.	
Brushite	$HCaPO_4.2H_2O$	Colourless	2·2	2–2·25	V.	V.	Occurs on rock-guano
Bunsenine, Bunsenite ..	NiO	Green	6·39	5·5	I.	Tc.	Occurs with nickel ores

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
CABRERITE	$(Ni,Mg)_3As_2O_8.H_2O$	Apple-green	2·9	2	V.	P.	Spanish nickel ore
Cacoxenite, Cacoxene ..	$(Fe_2(OH)_3PO_4)_2.9H_2O$	Yellow	3·4	3·5	V. or VI.	S.	
Cadmium ochre, *s.* Greenockite							
Cairngorm, *v.* Quartz	SiO_2	Smoky-yellow	2·6	7	III.	V.	Scotch precious [stone
Calaite, *s.* Turquoise							
Calamine	$(Zn.OH)_2SiO_3$	White, yellow	3·1-3·9	5	IV.	V., P.	Important zinc ore
Calamite, *s.* Tremolite							
Calaverite	$(Au,Ag)Te_2$	Yellowish-grey	9·04	2·5	—	M.	Au : Ag :: 6 : 1
Calcite	$CaCO_3$	All colours	2·6	3	III.	V., D.	Furnace flux; includes limestones [and marbles
Calcouranite, *s.* Autunite							
Calcspar, *s.* Calcite							
Caledonite	$(Pb,Cu)_2SO_4{\cdot}CO_3$	Green	6·4	3	V.	R.	Allied to Leadhillite
Callainite, Callait, *s.* Variscite							
Callais, Callaite, *s.* Turquoise							[artificially prepared
Calomel	Hg_2Cl_2	White, grey	6·5	1·5	II.	A.	Valuable medicine,
Cancrinite	$(Na_2,Ca)_4H_6(NaCO_3)_2Al_8Si_9O_{36}$	Colorless	2·45	5·5	V.		Altered Nephelite
Cannel Coal	—	Brown or black	—	—	—	E.	Gas manufacture
Capillary pyrites, *s.* Millerite							
Carbonado, *s.* Boart							
Carbuncle, *s.* Almandine							
Carnallite	$MgCl_2.KCl.6H_2O$	Red, white	1·6	3	IV.	V.	Magnesium. *See* p. 5756
Carnelian, *v.* Chalcedony ..	SiO_2	Bright red	2·7	7	Mc.	O.	Ringstone
Carpholite	$MnAl_2(OH)_4(SiO_3)_2$	Straw-yellow	2·9	5	V.	S.	
Cassiterite	$(SnO_2)_2$	Black-brown	6·8	6·5	II.	A.	Important tin ore [p. 6161
Castor, *s.* Petalite							
Cat's eye, *v.* Quartz	—	—	—	—	—	—	*See* p. 5855
Celadonite	Fe,Al,K,Mg,SiO	Olive-green	2·85	1·5	Am.	D.	
Celestite, Celestine	$SrSO_4$	Colourless, etc.	3·9	3–3·5	IV.	V.	Strontium nitrate; fireworks
Cerite, Cererite	$(Ce,Al,La,Di)_2CeO(Ca,Fe)(SiO_3)_3$	Grey	4·9	5	IV.	R.	Ce, La, or Di
Cerargyrite, *s.* Chlorargyrite							
Cerussite	$PbCO_3$	White, grey	6·4	3·5	IV.	A.	Lead (83·5 per cent.)
Cervantite	Sb_2O_4	Yellow, white	4·08	4·5	IV.	P.	Antimony (80 per [cent.)
Chabazite, Chabasie	Al,Ca, and SiO_3	White	2·1	4·5	III.	V.	
Chalcanthite	$CuSO_4.5H_2O$	Blue	2·2	2·5	IV.	V.	Fertiliser
Chalcedony, *v.* Quartz ..	SiO_2	All colours	2·7	7	Mc.	Gl.	Precious stone
Chalcocite, *s.* Copper glance	Cu_2S	Blackish	5·5	2·5–3	IV.	M.	Copper (79·8 per cent.)
Chalcodite, *s.* Stilpnomelane							
Chalcophyllite	$CuOH,AsO_4,7H_2O$	Emerald green	2·5	2·5	III.	P.	Called Copper Mica
Chalcopyrites, *s.* Copper-pyrites							
Chalcosine, *s.* Copper glance							
Chalybite	$FeCO_3$	Yellowish	3·4	5·7	Am.	D.	Iron ore (48 per [cent.)
Chamosite	$Fe_2(Fe,Mg)_3H_6Si_2O_{13}$	Black	3·3	2·5	III.	V.	
Chelmsfordite, *s.* Scapolite							
Chessylite, *s.* Azurite							
Chiastolite, *v.* Andalusite ..	$Al_2O.SiO_4$	Red, grey, brown	3·1	7	IV.	R.	
Childrenite	$Al(OH)_2(Fe,Mn,Ca)PO_4.H_2O$	Colourless	3·2	4·5	IV.	V.	[gunpowder, nitric acid
Chile saltpetre..	$NaNO_3$	White, etc.	2·1	1·75	III.	V.	Nitre; fertilisers,
Chiolite	$(AlF_3)_3.(NaF)_5$	Snow-white	2·86	3·75	II.	V.	
Chloanthite, *v.* Smaltite ..	$(CoFeNi)As_2$	Tin-white	6·8	5	I.	M.	Cobalt
Chlorargyrite	AgCl	Pearl-grey	5·5	1–1·5	I.	R.	Silver (75 per cent.)
Chlorite group	Al,Fe,Cr,Mg, Fe, and SiO_3	Various	1–6	1·85	V.	P.	
Chlorite-spar, Chloritoid ..	$Al_2(Fe,Mg)H_2SiO_7$	Green to grey	3·5	6	V.	V.	
Chloropal	$(Fe,Al)_2(SiO_3)_3.5H_2O$	Brown and green	1·7 – 1·8	1–1·75	Am.	R.	Similar to Nontronite
Chondrodite	$(Mg.OH)_2(MgF)_4(Mg,Fe)_{13}(SiO_4)_8$	Yellow-brown	3·1	6·5	V.	V.	
Christianite, *s.* Phillipsite							
Chrome-yellow, *s.* Crocoite							[chrome steel
Chromite	$FeCr_2O_4$	Iron-black	4·3	6	I.	Sm.	Chief chromium ore;
Chrysoberyl	$Be(AlO_2)_2$	Green, yellow	3·7	8	IV.	V.	Precious stone, p. 5855
Chrysocolla	$CuSiO_3.2H_2O$	Blue to green	2·2	2·4	Amor.	V.	Copper (36 p'r cent.)
Chrysolite, *v.* Olivine	$(Mg,Fe)_2SiO_4$	Green, yellow	3·4	7	IV.	V.	Precious stone, p. 5855
Chrysotile, *v.* Asbestos ..	—	—	—	—	—	—	Commercial asbestos
Cinnabar	HgS	Red	8·9	2–2·5	III.	A.	Mercury (85 per cent.); vermilion
Cinnamon stone, *v.* Garnet ..	$3SiO_2.Al_2O_3.CaO$	Honey-yellow	3·6	7–7·5	I.	V.	*See* p. 5855
Citrine, *v.* Quartz	SiO_2	Yellow	2·6	7	III.	V.	Is false topaz
Clarite, *s.* Enargite							
Clausthalite	PbSe	Lead-grey	7·6-8·8	2·5	I.	M.	Selenium
Clay, *s.* Kaolinite, Halloysite, etc.	—	—	—	—	—	—	Fire-bricks, paper-glazing, alum

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Clay ironstone, *s.* Chalybite ..	$FeCO_3$	Yellowish	3·4	3–7	Am.	D.	Variety of Siderite
Cleavelandite, *s.* Albite							
Clingmanite, *s.* Margarite							
Clinochlore	$H_8(Al,Fe,Cr)_2 (Mg,Fe)_5Si_3O_{18}$	Greenish-white	2·7	2·25	V.	P.	Chlorite group
Clinoclase, Clinoclasite ..	$(CuOH)_3AsO_4$	Bluish-green	4·2	2·75	V.	P.	
Clintonite, *s.* Seybertite							
Coal	C,H,O and ash	Black	1·4-1·6	2·5	Am.	R.–V.	Most common fuel
Cobalt bloom, *s.* Erythrite ..	$Co_3O_8As_2.8H_2O$	Crimson	2·9	2	V.	P.	Cobalt (29·5 per cent.)
Cobalt glance, *s.* Cobaltite							
Cobalt-ochre, *s.* Asbolite							
Cobalt pyrites, *s.* Linnæite ..	$(CoNi)_3S_4$	Steel-grey	4·9	5·5	I.	M.	Cobalt (57·9 per cent.), nickel
Cobaltite, Cobaltine	$CoAsS$	Silver-white	6	5·5	I.	M.	Cobalt (35·5 per cent.)
Cockscomb pyrites, *s.* Marcasite	FeS_2	Pale yellow	4·8	6–6·5	IV.	M.	Iron (46·6 per cent.) in jewellery
Colemanite	$Ca_2B_6O_{11}.5H_2O$	Colourless	2·4	4·25	V.	V.	
Coloradoite	$HgTe$	Greyish-black	8·6	3	Am.	M.	Mercury (61·5 per cent.), tellurium
Columbite (Niobite)	$Fe[(Nb,Ta)O_3]_2$	Black	6	6	IV.	M., A.	Niobium, tantalum
Comptonite, *s.* Thomsonite							
Connarite	$H_4Ni_2Si_3O_{10}$	Yellowish, etc.	2·5	2	III.(?)	P.	
Copalite, Copaline	$C_{12}H_{18}O$	Yellow, brown	1·01	2	Am.	R.	A fossil resin
Copiapite	$(FeOH)_2Fe_2(SO_4)_5.18H_2O$	Sulphur-yellow	2·1	2	V.	E.	
Copper	Cu	Red	8·9	2·75	I.	M.	Crystalline near igneous rocks
Copper froth, *s.* Tyrolite							
Copper glance	Cu_2S	Blackish	5·5	2·5–3	IV.	—	Copper (79·8 per cent.)
Copper green, *s.* Chrysocolla							
Copper mica, *s.* Chalcophyllite							
Copper pyrites	$CuFeS_2$	Brass-yellow	4·2	3·5–4	II.	M.	Copper, 34·5 per cent.
Copper vitriol, *s.* Chalcanthite							
Copperas, *s.* Melanterite							
Coquimbite	$(Fe,Al)_2(SO_4)_3.9H_2O$	Whitish, etc.	2·09	2·25	III.	—	Is White copperas
Cordierite (Iolite)	$(Al,Fe)_6Mg_3Si_8O_{28}$	Blue, green, grey	2·6	7	IV.	V.(?)	Highly dichroic
Corundellite, *s.* Margarite							
Corundum	Al_2O_3	Blue, red, etc.	4	9	III.	V.	Emery; sub-varieties are ruby, sapphire, etc.
Cotunnite	$PbCl_2$	Colourless	5·25	2	IV.	A.	Found in Vesuvian lava
Covellite, Covelline	CuS	Dark-blue	4	1·5–2	III.	Sm.	
Crispite, *s.* Rutile							
Crocidolite (Hornblende group)	$(Fe,Na)_2.(SiO_3)_4 FeSiO_3$	Blue to green	3·25	4	F.	S.	
Crocoite, Crocoisite	PbO_4Cr	Yellow	6	2·5–3	V.	Te.	Chrome-yellow
Cronstedtite	$Fe_2(Fe,Mg)_3.H_6Si_2O_{13}$	Black	3·3	2·5	III.	V.	
Cryolite	$Al_2F_6.6NaF$	White, etc.	3	2·5	V.	V.	Aluminium (12 per cent.); alums, glass, soda, page 5989
Cryptolite, *s.* Monazite							
Cube Ore, *s.* Pharmacosiderite							
Cupreine, *s.* Copperglance							
Cuprite	Cu_2O	Red	6	3·5–4	I.	Sm.	Copper (88 per cent.)
Cupro-uranite, *s.* Torberite							
Cyanite	$(AlO)_2SiO_3$	Blue, etc.	3·2	5·5	VI.	V.	
Cyprite, *s.* Copperglance							
DANAITE, *v.* Mispickel ..	$(FeCo)AsS$	White, grey	2·35	3	V.	P.	Cobalt ore
Danburite	$CaB_2(SiO_4)_2$	Yellow	3	7·25	IV.	V.	
Datolite, Datholite	$Ca(B.OH)SiO_4$	White	2·9	5	V.	V.	
Delawarite, *s.* Orthoclase							
Delvauxite, *s.* Dufrenite							
Demantoid, *v.* Andradite ..	- -	Green	3·83	6	I.	V.	*See* p. 5855
Descloizite	$(Pb,Zn)VO_4 (Pb.OH)$	Black to brown	5·8	3·5	IV.	V.	Discovered by Descloizeau
Desmine, *s.* Stilbite							
Deweylite	$Mg_4H_4Si_3O_{12}$	Yellow	2	2·5	Am.	R.	
Diaclasite, Diaclase, altered Enstatite							
Diadochite	Fe_2O_3,SO_3,P_2O_5 and H_2O	Yellowish	2	3	V.	R.	
Dialogite, *s.* Rhodochrosite ..	$MnCO_3$	Red, etc.	3·5	4	III.	V.	Manganese (47 per cent.)
Diamond	C	Colourless to black	3·5	10	I.	A.	Precious stone; glass and gem cutting
Diaphorite	$(PbAg_2)_5Sb_4S_{11}$	Steel-grey	5·9	2·5–3	IV.	M.	Similar to Freieslebenite
Diaspore	$AlO.OH$	White	3·4	6	IV.	V.	Aluminium; similar to Bauxite
Diatomite, *s.* Tripolite							
Dichroite, *s.* Cordierite							
Dickinsonite	$(Mn,Ca,Fe,Na_2)_{12}(PO_4)_8 3H_2O$	Grey	3·3	3·5	V.	V.	
Dicksbergite, *s.* Rutile							
Dihydrite, *s.* Phosphorochalcite							
Dillenburgite, *s.* Chrysocolla							
Diopside (Augite group) ..	$Mg,Fe,Ca(SiO_3)_4$	Green, white	3·3	6	V.	V.	Feebly translucent
Dioptase	CuH_2SiO_4	Emerald-green	3·2	4·75	III.	V.	

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Diphanite, *s.* Margarite							[building-stone ;
Disthene, *s.* Cyanite							[basic steel
Dolomite	$(CaMg)CO_3$	White, grey, etc.	2·8	3·5–4	III.	V.	Lime ; marble,
Domeykite	Cu_3As	Tin-white	7·5	3·25	Mass.	M.	Chilian copper ore
Dufrenite	$Fe_2(OH_3)PO_4$	Leek-green	3·3	3·25	IV.	V.	
Dufrenoysite	$Pb_2As_2S_5$	Lead-grey	5·5	3	IV.	M.	
Dumortierite	$Al_2(AlO)_6(SiO_4)_3$	Bright blue	3·2	7	IV.	V.	Strongly pleochroic
Durangite	$Na(AlF)AsO_4$	Orange-red	4	5	V.	V.	
Dysanalyte	$Na_2(CaFe)_8.Ce(NbO_3)_3Ti_{10}O_{29}$	Iron-black	4·1	5·5	I.	Sm.	In limestone
Dyscrasite	Ag_3Sb	Silver-white	9·5	3·5	IV.	M.	Silver
EARTHY COBALT, *s.* Asbolan	$MnO_2CoO, CuOH_2O$	—	—	—	—	—	Alteration product varies greatly
Edelite, *s.* Prehnite							
Edwardsite, *s.* Monazite							
Eggonite, *s.* Barytes							
Ehlite, *v.* Phosphorochalcite ..	$Cu(CuOH)_4(PO_4)_2.H_2O$	Emerald-green	4	2	—	P.	Similar to Pseudo-malachite
Ekebergite, *v.* Scapolite ..	$Al_2(AlO)Ca_4(Si_2AlO_8)_3$	White	2·7	5·5	II.	V.	
Elæolite, *v.* Nephelite ..	$Al_8(Na_2,K_2$ or $Ca)_4Si_9O_{34}$	Reddish, greenish	2·6	6	III.	G.	
Electro-silicon, *s.* Tripolite							
Electrum, *v.* Gold	xAu + yAg	Yellowish-white	12·5–15·5	2·5	I.	M.	A natural alloy used by ancients
Embolite	$Ag_2(ClBr)$	Grey-green	5·9	1–1·5	I.	A.	Silver (about 64 per cent.)
Emerald, *v.* Beryl	$Be_3Al_2(SiO_3)_6$	Green	2·6-2·8	7·5	III.	V.	Precious stone ; p. 5855
Emerald, Oriental, *v.* Sapphire	Al_2O_3	Green	4	9	III.	V.	An emerald-coloured sapphire
Emerald nickel, *s.* Zaratite ..	$3NiO.CO_2.6H_2O$	Emerald-green	2·6	3	Am.	V.	Nickel (46 per cent.)
Emery, *v.* Corundum	Al_2O_3	Black	4	9	III.	V.	Coloured by Magnetite; abrasive
Empholite, *s.* Diaspore							
Emplectite	$Cu_2(Bi,S_2)_2$	Tin-white to grey	5·15	2·5	IV.	M.	
Enargite	Cu_3AsS_4	Iron-black	4·4	3	IV.	M.	
Enceladite, *s.* Warwickite							
Endlichite	$Pb[(As,V)O_4]_3Cl$	Red, brownish	7	3	III.	R.	Perhaps *v.* of Va-[nadinite
Enstatite	$(MgFe)SiO_3$	Brown, green	3·2	5–5·5	IV.	P.	
Eosphorite, *v.* Childrenite ..	$(Mn,Fe)H_2O.AlPO_4$	Pink, yellowish, etc.	3·13	5	IV.	V.	
Epidote	$Al_2(Al.OH)Ca_2(SiO_4)_3$	Green, etc.	3·5	6·5	V.	V.	Common rock constituent
Epsom salt, *s.* Epsomite							
Epsomite	$MgSO_4.7H_2O$	White, yellow, red	1·7	2·25	IV.	V.	Artificial salt used in medicine
Eremite, *s.* Monazite							
Erinite	$Cu_3As_2O_8.2Cu(OH)_2$	Emerald-green	4·04	4·5–5	Mc.	D.	From Cornwall
Erubescite	Cu_3FeS_3	Reddish-yellow	5	3·5	I.	M.	Copper (55 per [cent.)
Erythrite, Erythrine	$Co_3O_8As_2.8H_2O$	Crimson	2·9	2	V.	P.	Cobalt (29 per cent.)
Euchroite	$((CuOH)CuAsO_4.3H_2O$	Emerald-green	3·4	3	IV.	V.	Copper
Euclase	$(AlOH)BeSiO_4$	Colourless	3·1	7·5	V.	V.	Very brittle
Eudialyte	$(Na,K,H)_{13}(Ca,Fe)(Zr,Si)_{20}O_{52}$	Rose, etc.	2·92	5·25	III.	V.	
Eudnophite, *s.* Analcite							
Eulytite, Eulytine	$Bi(SiO_4)_3$	Brown, yellow	6	5	I.	A.	Similar to Agricolite
Euxenite	$R(NbO_3)_2R_2(TiO_3)_3,H_2O$	Brownish-black	4·6	6·5	IV.	M., V.	R is Y, Er, Ce, U ; possibly Ge
FAHLERZ, *s.* Tennantite *and* Tetrahedrite							
Faröelite, *v.* Thomsonite ..	$2Al_2(Ca,Na_2)(SiO_4)_3,H_2O$	White	2·3	5·5	IV.	V.	From Hebrides, Faroe Is.
Fassaite, *v.* Augite	$MgCa(SiO_3)_2$	Green	3·3	5	V.	V.	Also called Pyrgom
Fayalite (Olivine group) ..	Fe_2SiO_4	Light yellow	4	6·5	IV.	—	Metalloidal lustre
Felspar group	$Al_2SiO_3(K,Na,$ Mg or $Ca)SiO_3$	Various	2·5	6	V.	V., P.	Pottery glaze. Varieties : Orthoclase, Oligoclase, Albite
Fergusonite	$Y(Nb,Ta)O_4$	Brownish-black	5·8	5·75	II.	D.	
Feltbol, *s.* Chloropal							
Fibroferrite	$Fe_6(OH)_8(SiO_4)_5,H_2O$	Honey-yellow	1·84	3·25	V.(?)	P.	
Fibrolite	$Al(AlO)SiO_4$	Grey, brown	3·2	6·5	IV.	R.	Dimorphic with [Cyanite
Figure Stone, *s.* Agalmatolite							
Fiorite, *v.* Opal	H_2O,SiO_2		2	5	Am.	W.	A volcanic sinter, Fiora, Tuscany
Fireblende, *s.* Pyrostilpnite							
Flint, *v.* Quartz	SiO_2	White, grey, etc.	2·7	7	Mc.	Gl.	Gun-flints ; building-stone, road metal, pottery
Flos ferri, *v.* Aragonite							
Fluor, Fluorite (Fluorspar) ..	CaF_2	All colours	3·2	4	I.	V.	Metallurgical flux, glass-making, HF, paints
Foresite, *s.* Stilbite							
Forsterite (Olivine group) ..	Mg_2SiO_4	White	3·2	6–7	IV.	V.	In volcanic ejections, etc.

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Fowlerite, *s.* Rhodonite							
Franklinite	$(FeZnMn)(Fe_2Mn_2)O_4$	Iron-black	5·15	6	I.	M.	Zinc (10 per cent.); [spiegeleisen
Freibergite, *s.* Tetrahedrite							
Freieslebenite	$(Pb,Ag_2)_5Sb_4S_{11}$	Grey	6·2	2·5	V.	M.	Lead (30 per cent.), silver (to 27 per cent.)
Frenzelite	$Bi_2(Se,S)_3$	Bluish-grey	6·4	3	IV.	M.	Selenium
Fullers' earth, *s.* Smectite	—	—	—	—	—	—	Grease absorbent for woollen fabrics
GADOLINITE	$Fe[Be(YO)SiO_4]_2$	Black, brown	4–4·5	6·75	V.	V.	
Gahnite (Spinel group)	$(Zn,Fe)(AlO_2)_2$	Greyish, green	4·3	7·75	I.	V.	A zinc spinel
Galena, Galenite	PbS	Lead-grey	7·5	2·5	I.	Sp.	Lead (86 per cent.); stoneware glaze, [p. 5985
Galmei, *s.* Calamine							
Garnet group	$R_2R_3(SiO_4)_3$	All except blue	3·1-4·3	7	I.	V.	Very many varieties; R_2 may be Al, Fe, Cr; R_3, Ca, Fe, Mn
Garnierite	$(Ni,Mg)H_2SiO_4$	Pale green	2·5	2·5	Am.	D.	Nickel (7 to 10 per cent.), p. 5982
Gaylussite	$(Na_2.Ca)(CO_3)_2 5H_2O$	White	1·94	2·5	V.	V.	
Gehlenite	$(AlO)_2(Ca,Mg,Fe)_3(SiO_4)_2$	Green, brown	3	5·5	II.	G.	
Genthite	$(Mg,Ni)_2H_4Si_3O_{10}$	Green	2·4	2	Am.	R.	Garnierite is impure variety of this
Gersdorffite	$Ni(Fe)SAs$	White, grey	6	5	I.	M.	Nickel-glance; nickel (35 per cent.)
Gibbsite	$AlPO_4(H_2O)_4$	White, etc.	2·35	3	V.	P.	
Gilsonite, *s.* Uintahite							
Girasol, *v.* Opal	SiO_2,H_2O	Hyacinth-red	2	5	Am.	V.	Called Fire opal; from Mexico
Gismondite, Gismondine	$CaAl_2(SiO_3)_4.4H_2O$	Colourless, white	2·2	4·5	V.	V.	
Glaserite, *s.* Aphthitalite							
Glauber salt, *s.* Mirabilite							
Glauberite	$Na_2Ca(SO_4)_2$	White, grey	2·7	3	V.	V.	
Glaucodote	$(Fe,Co)AsS$	Greyish, white	5·9	5	IV.	M.	Cobalt
Glauconite	Fe,K,SiO_2 and H_2O	Olive, etc.	2·3	2	Am.	D.	A variable mixture
Glaucophane (Hornblende group)	$NaAl(SiO_3)_2 Fe,Mg,SiO_3$	Blue	3·1	6–6·5	V.	V. to P.	In crystalline schists
Gmelinite	$(Na_2Ca)Al_2(SiO_3)_4,H_2O$	Colourless, etc.	2·1	4·5	III.	V.	
Goethitite	$FeO.OH$	Brown	4	4·5	IV.	A.	Iron (62 per cent.)
Gold	Au	Gold-yellow	15·6–19·5	2·5	I.	M.	Usually alloyed with silver
Goslarite	$ZnSO_4.7H_2O$	White, grey	2	2·25	IV.	V.	Called White vitriol
Göthite, *s.* Goethite							
Grahamite	Hydro-carbon	Black	1·4	2	Am.	B.	Illuminating gas
Gramenite, *s.* Chloropal							
Grammatite, *s.* Tremolite							
Granatite, *s.* Staurolite							
Graphite	$C (Fe_2O_3$, etc.)	Iron-black	2·15	1	III.	M.	[stove-polish, paints Lubricant, crucibles
Grastite, *s.* Clinochlore							
Greenockite	CaS	Yellow to orange	4·8	3	III.	A.	Nearly transparent
Greenovite, *v.* Sphene	$CaSTiO_5$	Brown, green, etc	3·5	6	V.	G.	
Greenstone, Green vitriol, *s.* Melanterite							
Grossularite (Garnet group)	$Al_2Ca_3(SiO_4)_3$	Pale green	3·4-3·7	7	I.	V.	Includes all Ca-Al garnets
Grothite, *s.* Sphene							
Guanite, *s.* Struvite							
Guarinite	$CaTiSiO_5$	Yellow	3·48	6	IV.	A.	
Guayacanite, *s.* Enargite							
Guitermanite	$(PbS)_{10}(As_2S_3)_3$	Bluish-grey	5·9	3	Mass.	M.	Opaque
Gummite	$(Pb,Ca,Ba)SiU_3O_{12}.H_2O$	Reddish	4·1	2·75	—	G.	
Gymnite, *s.* Deweylite							
Gypsum	$CaSO_4.2H_2O$	White, grey, etc.	2·3	2	V.	V.S.	Plaster of Paris, artif. marble, fertiliser, cements
HÆMATITE	Fe_2O_3	Steel-grey, dark red	4·8–5	5·5-6·5	III	M., E.	Iron (70 per cent.), polishing powder, crayons, red paint
Hairsalt, *s.* Keramohalite							
Halite, *s.* Salt							
Hallite, *s.* Aluminite							
Halloysite	$Al_2H_4Si_2O_9,H_2O$	White, yellow, red	2·5	2	Am.	R.	Variety of Kaolinite
Halochalcite, *s.* Atacamite							
Halotrichite	$FeSO_4.Al_2(SO_4)_3H_2O$	White	1·95	—	V. or VI.	S.	An iron alum
Hamartite, *s.* Bastnäsite							
Hanksite	$(Na_2)_5CO_3 (SO_4)_4$	White	2·56	3·25	III.	V.	
Harmotome	$Al_2(Ba,Ca_2,Na_2,K_2)Si_6O_{16}$	White	2·4	5	V.	V.	
Harringtonite, *s.* Mesolite							
Hatchettolite	U,Ti,Nb,W,Sn,Ca,Y,Fe,K,Na, and H_2O	Yellowish-brown	4·8	5	I.	R.	Translucent

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Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Hauerite	MnS_2	Reddish-brown	3·4	4	I.	Sm.	
Hausmannite	Mn_3O_4	Brown	4·7	5·5	II.	M.	Manganese (71 per [cent.) ; rare
Haüynite, Haüyne	Ca,Na,(AlNa SO_4),$Al_3(SiO_4)_4$	Blue	2·4	5	I.	V. to R.	In Lapis lazuli. *See* p. 5856
Hayesine, *s.* Ulexite							
Heavy spar, *s.* Barytes							
Hebronite, *s.* Amblygonite							
Hedenbergite	$FeCa(SiO_3)_2$	Green	3·5	5	V.	V.	Augite group
Heliotrope, *s.* Bloodstone							
Helvite, Helvine	(Mn,Be,Fe),S.$(SiO_4)_3$	Yellow, brown	3·2	6	I.	R.	A tetrahedral garnet
Hematite, *s.* Hæmatite							
Hemimorphite, *s.* Calamine							
Herderite	$Ca[Be(OH.F)]PO_4$	White	3	5	IV.	V.	
Herrengrundite	$Ca(OH_2).2CuOH.2SO_4.3H_2O$	Emerald-green	3·1	2·75	V.	P.	
Hessite	Ag_2Te	Grey	8·5	2·5	I.	M.	Au also present
Hessonite, *s.* Grossularite ..	$Al_2Ca_3(SiO_4)_3$	Cinnamon-brown	3·5	7	I.	V.	Wrongly Hyacinth. *See* page 5855
Houlandite	$Al_2(Ca,Sr)H_4(SiO_3)_6$	White, red	2·2	4	V.	V.	
Hiddenite, *s.* Spodumene							
Hisingerite	FeO,SiO_2,H_2O, etc.	Black	2·75	3	Am.	G.	Probably a mixture
Honey-stone, *s.* Mellite							
Hornblende group	$(Mg,Fe)_3Ca(SiO_3)_4$	Blackish-green	3·1	5·5	V.	V.	Fibrous variety is [Asbestos
Hornquicksilver, *s.* Calomel							
Hornsilver, *s.* Chlorargyrite							
Hortonolite	$(Fe,Mg)_2SiO_4$	Yellow	3·9	6·5	IV.	V.	In chrysolite group
Hübnerite	$(Fe,Mn)WO_4$	Black	7·2	5	V.	Sm.	Tungsten
Humboldtine, *s.* Oxalite							
Humboldtite, *s.* Datolite							
Humite	$Mg_{13}(MgF)_4(MgOH)_2.(SiO_4)_8$	White	3·1	6–6·5	IV.	V.	Chondrodite group
Hyacinth	$ZrSiO_4$	Pink	4·65	7·5	II	A., R	Precious stone
Hyalite, *v.* Opal ..	SiO_2,H_2O	Colourless	2	6	Am.	V.	Transparent, the purest form
Hyalophane (Felspar group) .	$KBaAl_3Si_5O_{16}$	Colourless	2.8	6·25	V.	V.	Transparent
Hydrargyrite, *s.* Wavellite							
Hydrocyanite	$CuSO_4$	Pale green	—	2·25	IV.	—	Is anhydrous Chal- [canthite
Hydrohematite, *s.* Turgite							
Hydromagnesite	$3MgCO_3.Mg(OH)_2.H_2O$	White	2·14	3·5	V.	V.	
Hydrotalcite	$Al(OH)_3[Mg(OH)_2]_3.3H_2O$	White	2·07	2	III.	P.	
Hydrozincite	$(Zn.OH)_2Zn(OH_2)CO_3$	White, etc.	3·7	2·25	Mass.	D.	Earthy variety of Smithsonite
Hypersthene (Enstatite group)	$(MgFe)SiO_3$	Brown	3·4	6	IV.	V.R.	Variety of Pyroxene
ICELAND SPAR, *v.* Calcite..	$CaCO_3$	Colourless	2·6	3	III.	R.	Doubly refracting: [optical instruments
Ichthyopthalmit, *s.* Apophyllite							
Idocrase	$(AlO_2)_{12}(OH.Si_2)_{10}O_{77}$	Brown, grey, etc.	3·4	7	II.	R.	Frequently contains Fe
Ilmenite	$(TiFe)_2O_3$	Iron-black	4·7	6	III.	M.	Titanium (31 per cent.); worthless [for iron
Ilmenorutile, *v.* Rutile							
Ilvaite	$Fe_2Ca(FeOH)(SiO_4)_2$	Black	4	5·75	IV.	R.	
Indicolite, *v.* Tourmaline ..	*See* Tourmaline	Blue	3·1	7·5	III.	V.	*See* p. 5856
Iodargyrite	AgI	Yellow	5·7	2	III.	A.	Silver (46 per cent.)
Iodyrite *s.* Iodargyrite							
Iolite, *s.* Cordierite							
Iridosmine	Ir and Os with Pt metals	Tin-white	19–21	6–7	III.	M.	Gold-nib points, draw-plates, weight standards, ceramic enamel
Iron	Fe	Steel-grey	7·5	6	I.	M.	In meteorites, with [Ni, Co, etc.
Iron froth and glance, *s.* Hæmatite							
Iron pyrites, *s.* Ilvaite							
JACOBSITE	$2FeMnO_2.Mn$	Black	4·75	6	I.	M.	
Jacynth, *s.* Hyacinth							
*Jade	—	—	—	—	—	—	Chinese jade, used [for carving
Jadeite	$NaAl(SiO_3)_2$	Green	3·3	6·5–7	V., VI.	Sv.	
Jamesonite	$Pb_2Sb_2S_5$	Grey	5·7	2·5	IV.	M.	Devonshire antimony ore
Jargoon, *v.* Zircon	$ZrSiO_4$	Colourless, yellowish	4·5	7·5	II.	A.	Diamond substitute. *See* p. 5855
Jarosite	$FeO_3K(SO_4)_2 3H_2O$	Brown	3·25	3·5	III.	V.	
Jasper, *v.* Quartz	SiO_2, with Al_2O_3, Fe_2O_3, etc.	Red, yellow, green, etc.	2·7	7	Mc.	V.,O.	Coloured by impurities; carved ornaments
Jefferisite	$(Al,Fe,Mg)_4(SiO_4)_5.6H_2O$	Yellow	2·3	1·5	—	P.	Chlorite group
Jet	C,H,O, etc.	Black	—	—	Am.	V.	Resembles Cannel [coal; jewellery
Jordanite	$Pb_4As_2S_7$	Lead-grey	6·39	3	IV.	M.	

* Jade includes various minerals, of which the chief species are Jadeite and Nephrite (q.v.)

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
KAINITE	$KCl,MgSO_4,3H_2O$	Yellow	2.1	2·5	V.	V.	Fertiliser
Kalinite	$KAl(SO_4)_2.12H_2O$	White	1·75	2	I.	V.	Is potash alum. *See* Alum
Kaolin, Kaolinite	$Al_2O_3.2SiO_2.2H_2O$	White	2·5	1–2	V.	P. to D.	Porcelain, paper-making, chemical products
Keatingine, Keatingite *s.* Fowlerite							
Keramohalite	$Al_2(SO_4)_3.18H_2O$	White	1·7	2	V.	S., P.	
Kermesite	Sb_2OS_2	Cherry-red	4·5	1·5	V.	A.	Antimony (75 per cent.)
Kidney ore	—	—	—	—	—	—	Is Chalybite with Calcite veins
Kieserite	$MgSO_4.H_2O$	White, grey	2·5	3	V.	Gl.	
Klapothrite, *s.* Lazulite							
Knebelite	$(Fe,Mn,Mg)_2SiO_4$	Grey	3·9	6·5	IV.	Tc.	Olivine group
Kongsbergite, *s.* Amalgam							
Kraurite, *s.* Dufrenite							
Krennerite	Ag,Au,Te	White to yellow	8·3	—	IV.	M.	Composition uncertain
Kreuzstein, *s.* Harmotome							
Kuhnite, *s.* Berzeliite							
Kupferschaum, *s.* Tyrolite							
Kyanite, *s.* Cyanite							
LABRADORITE	$(AlSi_2)_2(Na,Ca)SiO_8,AlO_8$	White, grey	2·7	6	VI.	V. to R.	Felspar group; cut for cameos
Langbanite	$(Mn,Fe)_{22}Sb_2Si_4O_{35}$	Iron-black	4·9	6·5	III.	M.	
Langite	$[Cu_2(OH)_3]_2SO_4.H_2O$	Blue	3·49	2·75	IV.	V.	Translucent
Lanthanocerite, *s.* Cerite							
Lapis lazuli, *v.* Haüynite ..	$(Na_2,Ca)AlSiO_4$ (?)	Azure-blue	2·3	5·5	I.	G. to V.	In jewellery. *See* p. 5856
Lasurite, *s.* Lapis lazuli							
Laumontite, Laumonite ..	$Al_2(OH)_4Ca(Si_2O_5)_2.2H_2O$	White, yellow, red	2·3	3·5	V.	V., S.	In Canadian copper ores, etc.
Laurionite	PbOHCl	Colourless	—	3·25	IV.	A., S.	
Lazulite	$(Al.OH)_2(Mg,Fe,Ca)(PO_4)_2$	Blue	3	5·3	V.	V.	
Lazurite, *s.* Lapis lazuli							
Lead	Pb	Grey	11·37	1·5	I.	M.	*See* Index
Leadhillite	$4PbO.SO_3.2CO_2.H_2O$	White, yellow, etc.	6·3	2·5	V.	R.	In Lanarkshire
Lecontite	$(Na,NH_4,K)_2SO_4.2H_2O$	Colourless	2·4	2–2·5	IV.	V.	
Ledererite, *s.* Gmelinite							
Lederite, *s.* Titantite							
Lepidocrocite, *s.* Göthite							
Lepidolite	$Al_3Fe(Li,K,Na)_3(OH,F)_2Si_5O_{16}$	Violet, red	2·9	2·5	V.	P.	Mica group
Leucite	$AlK(SiO_3)_2$	Grey, white	2·5	6	I.	V.toR.	
Leucocyclite, *s.* Apophyllite							
Leucopyrite, *s.* Löllingite							
Levynite, Levyne	$CaAl_2Si_3O_{10}.5H_2O$	Colourless, etc.	2·12	4·25	III.	V.	Strongly doubly refracting
Libethenite	$(CuOH)CuPO_4$	Green	3·7	3·5	IV.	G.toV.	
Lievrite	$(FeOH)Fe_2Ca(SiO_4)_2$	Black	3·9	5·75	IV.	U.	Resembles Ilvaite
Lignite	C,H,O,N,S, etc.	Brown to black	1·4	2·5	Am.	R.	Brown coal, very abundant, almost worthless
Ligurite, *s.* Titanite							
***Limestone**							
Limonite	$2Fe_2O_3.3H_2O$	Brown	3·7–4	5·5	Am.	G., V., S.	Brown hæmatite. Iron (59 per cent.); polishing, paint
Linarite	$PbCu.(OH)_2SO_4$	Azure blue	5·4	2·75	V.	A.toV.	
Linnæite	$(Ni,Co,Fe)_3S_4$	Greyish black	4·9	5·25	I.	M.	Cobalt (57 per cent)
Liparite, *s.* Fluor							
Liroconite	$Al_4Cu_9(OH)_{15}(AsO_4)_5.20H_2O$	Bluish-green	2·8	2·75	V.	V. to G.	With Olivenite
Lithiophilite	$Li(Mn,Fe)PO_4$	Clove-brown	3·5	4·75	IV.	V.toR.	
Lithiophorite, *s.* Wad ..	$MnO_4.H_2O$, Li and Al	Bluish-black	3·2	3	—	D.	
Lithographic stone	—	—	—	—	—	—	A buff, compact limestone
Löllingite	$FeAs_2$	Tin-white	6·8	5	IV.	M.	
Ludwigite	$Mg_2O.FeO_2.BO_2$	Blackish-green	4	5	IV.	S.	Strongly pleochroic
Lydian stone, *v.* Quartz ..	SiO_2	Velvet-black	—	—	Mc.		Touchstone for gold (p. 5850)
MAGNESITE	$MgCO_3$	White, yellow, etc.	3	4·5	III.	V., D.	Basic-steel hearths; paper-pulp bleach, fire-proofing
Magnetite	Fe_3O_4	Iron-black	5	5·5	I.	M.	Principal iron ore (72 per cent.)
Magnetopyrite, *s.* Pyrrhotite							
Malachite	$(CuOH)_2CO_3$	Emerald-green	3·8	3·5	V.	V.,P.	Copper (57 per cent.); ornaments, jewellery, pigment
Malacolite, *s.* Diopside							
Malthazite, *s.* Smectite							

* **Limestones are only impure massive Calcite or Dolomite; varieties very numerous, depending on impurities; largely used in building**

Minerals.	Chemical formula or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Manganite	$MnO.OH$	Black, steel-grey	4·3	4·25	IV.	M.	Manganese (60 per cent.)
Manganocalcite, *s.* Rhodocrosite							
Manganostibiite	$Mn_2(Mn_8O_7)(Sb,As)O_4$	Black	—	—	IV.	O.	Found in embedded grains
*Marble							
Marcasite	FeS_2	White, yellow	4·7	6	IV.	M.	Iron (46 per cent.); jewellery
Marceline, *s.* Braunite							
Margarite	$H_2CaAl_4Si_2O_{12}$	White, grey, green	3	4·5	V.	P.	
Margarodite, *s.* Muscovite							
Marionite, *s.* Hydrozincite							
Martite	Fe_2O_3	Black	5	6–7	I.	Sm.	Iron (70 per cent.) A pseudomorph:
Matlockite	$PbOCl_2$	Yellowish	7·2	2·75	II.	A.	Translucent
Meerschaum	$Mg_2H_4Si_3O_{10}$	White	0·98–1·27	2·25	Am.	D.	Porous; tobacco pipes
Meionite	$Cu_4Al_2(AlO)(Si_2AlO_8)_3$	Colourless to white	2·7	5·75	II.	V.	
Melaconite	CuO	Iron-black	6	5	Y.	M.	Black copper ore (79 per cent.)
Melanophlogite	$Fe.SO_3$, and C	Brown, colourless	2·03	6·75	—	V.	Pseudo-isometric or II.
Melanterite	$FeSO_4.7H_2O$	Green	1·8	2	V.	V.	Copperas; commercially from pyrites
Mellite	$Al_2C_{12}O_{12}.18H_2O$	Yellow, brown	1·5	3	II.	G.	In Coal, Lignite, etc.
Menaccanite, *v.* Ilmenite ..	$(Ti,Fe)_2O_3$	Iron-black	4·7	6	III.	M.	Ti makes it worthless as iron ore
Mendipite	$Pb_3O_2Cl_2$	Yellow	7·1	3	IV.	A.	
Mendozite	$Na_2SO_4.Al_2(SO_4)_3.24H_2O$	White	1·8	3	Fi.	V.	Soda alum; calico-printing, soap making
Mercury	Hg, with Ag	Tin-white	13·5	—	I.	M.	Occurs liquid; in arts, science, and medicine
Mesolite	Na,Al,Ca,SiO_3 and H_2O	White, colourless	2·3	5	IV. & V.	V.	Between Natrolite and Scolecite
Mesotype, *s.* Mesolite, Natrolite, and Scolecite							
Metacinnabarite	HgS_8	Greyish-black	7·8	3	I.	M.	Similar to Cinnabar
Miargyrite	$AgSbS_2$	Grey to black	5·3	3	V.	M.	Silver *See* p. 812
†Mica							
Microcline (Felspar group) ..	$(K,Na)AlSi_3O_8$	White, yellow, etc.	2·5	6·25	VI.	V., P.	*See also* Amazon Stone
Microlite	$Ca_2Ta_2O_7$	Yellow to brown	5·5	5·5	I.	R.	Mn, Fe, Mg, K, and Na also present
Millerite	NiS	Yellow	5	4	III.	M.	Nickel (64 per cent.)
Mimetesite, Mimetite ..	$PbCl_2.3Pb_3As_2O_8$	Yellow, brown, etc.	7·1	3·5	III.	R. to A.	Lead. *See* p. 5985
Mineral coal, *s.* Anthracite							
Mineral wax, *s.* Ozokerit							
Minium	Pb_3O_4	Red	4·6	2·5	Am.	G., D.	*See* p. 5988
Mirabilite	$Na_2SO_4.10H_2O$	White	1·5	1·75	V.	V.	Glauber's salt
Mispickel	$FeAsS$	Tin-white	6	5·5	IV.	M.	Arsenopyrite, arsenic (46 per cent.)
Misy, *s.* Copiapite							
Mixite	$BiCu_{10}(OH)_8(AsO_4)_5.7H_2O$	Green	3·79	3·5	V. or VI.		Translucent to transparent
Mizzonite, *s.* or *v.* Wernerite							
Molybdenite	MoS_2	Reddish-grey	4·6	1·5	III.	M.	Molybdenum (60 per cent.)
Monazite	$(Ce,La,Di)PO_4$	Red, brown	5	5·25	V.	R.	Found as sand; gas mantles
Montebrasite, *s.* Amblygonite							
Monticellite	$Ca(Mg,Fe)SiO_4$	Colourless, etc.	3·15	5·25	IV.	V., R.	Olivine group
Montmorillonite	$H_2Al_2Si_4O_{12}$ (?)	Rose-red	2	1	Am.	W.	Soapy feel
Moonstone, *v.* Orthoclase *and* Oligoclase	Al,K,Na,Si_3O_8	White	2·5	6	V. & VI.	V.	Precious stone
Morvenite, *s.* Harmotome							
Moss agate, *v.* Quartz	SiO_2	Dark green	2·6	7	III.	V.	Contains dendritic MnO_2; jewellery
Mountain cork, *s.* Asbestos							
Mundic, *s.* Pyrites							
Muscovite (Mica)	$(K,Na)H_2Al_3(SiO_4)_3$	Grey, white, etc.	3	2·5	V.	P., Tp	In most granites; glass substitute, stove-doors, wall-paper mfr., electrical apparatus
NACRITE, *v.* Kaolinite ..	$Al_2O_3.SiO_2,2H_2O$	White	2·3-2·6	0·5–1		P.	
Nagyagite	$Au_2Pb_{14}Sb_3(S,Te)_{24}$	Grey to black	6·9	1·5	IV.	M.	Gold, a sulpho-telluride
Natrocalcite, *s.* Gaylussite							
Natrolite	$Al_2(SiO_4)_3Na_2H_4$	White, yellow, red	2·2	5	V. & IV.	V.	Dimorphic
Natron	$Na_2CO_3.10H_2O$	White	1·4	1–1·5	V.	V., E.	In solution in soda-lakes, Egypt, etc.
Necronite, *s.* Orthoclase							
Needle ore, *s.* Aikinite							
Neotocite	Mn,SiO_3,H_2O	Black to brown	2·75	3·5	Am.	Sm.	Opaque
Nephelite, Nepheline ..	$Al_8(Na_2K_2Ca)_4Si_9O_{34}$	White, grey, etc.	2·6	6	III.	V., R.	
Nephrite, *v.* Amphibole ..	$\left.\begin{matrix}Ca\\Fe\end{matrix}\right\} Mg_3(SiO_3)_4$	White to green	2·9-3·1	6–6·5	V.	V.	Carved into ornaments by early man; may be Actinolite or Tremolite

* Marbles are impure massive Calcite or Dolomite; many varieties, largely used in building

† Mica group includes many different minerals having similar cleavage. Commercial mica is Muscovite or Biotite

Minerals.	Chemical formula or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Nesquehonite	$MgCO_3.3H_2O$	Colourless to white	1·83	2·5	IV.	V., G.	Transparent to translucent
Newjanskite, *s.* Iridosmine							
Niccolite	NiAs, with Fe, Co,Sb	Copper-red	7·5	5·25	III.	M.	Nickel (43 per cent.)
Nickel bloom, *s.* Annabergite							
Nickeline, *s.* Niccolite							
Niobite, *s.* Columbite							
Nitre (Saltpetre)	KNO_3	White	2	2	IV.	V.	Gunpowder, nitric acid, medicine, metallurgy, pyrotechnics.
Nontronite	$Fe_2O_3.3SiO_2.5H_2O$	Yellow	2	2–4	Mass.	O.	Very similar to Chloropal
Nosite, Nosean..	$Al_3Na_5(Al,Na SO_4).(SiO_4)_4$	Grey, etc.	2·3	5·5	I.	V. to R.	
OBSIDIAN (a rock)	$KNa_3Al_2Si_{10}O_{25}$	Black, grey	2·2-2·8	7	Am.	V.	Principally Orthoclase; as pumice, polishing powder
Ochroite, *s.* Cerite							
Octahedrite, *s.* Anatase							
*Odontolite							
Oligoclase (Felspar group) ..	$Al_3.Na,Ca,Si_5O_8$	Green, white, etc.	2·56	6	VI.	R.	Common rock constituent
Olivenite	$(CuOH)CuAsO_4$	Green	4·3	3·5	IV.	V., S.	
Olivine (Olivine group) ..	$(Mg,Fe)_2SiO_4$	Green, yellow	3·4	7	IV.	V., R.	Includes Peridot and Chrysolite
Omphacite, *v.* Augite	$Mg,Ca(SiO_3)_2$	Green	3·2	6	V.	V.	
Onofrite	Hg(Se,S)	Black-grey	8·05	2·5	I.	M.	Opaque
Onyx, *v.* Agate	SiO_2	Various			Mc.		Mexican onyx is impure Calcite
Opal	$SiO_2.xH_2O$	All colours	2	5	Am.	V.,W.	Precious opal has a play of colours
Ophite, *s.* Picrolite							
Orangite, *s.* Thorite							
†Oriental amethyst, etc.							
Orpiment	As_2S_3	Lemon-yellow	3·48	2	IV.	R.	Arsenic (61 p.c.); king's yellow
Orthite, *s.* Allanite							
Orthoclase (Potassium Felspar)	$Al(K,Na)Si_3O_8$	White, red, etc.	2·5	6	V.	V.	Porcelain glaze; jewellery
Osmiridium, *s.* Iridosmine							
Oxalite	$(FeC_2O_4)_2.3H_2O$	Yellow	2·2	2	Mc.	Gl.	
Ozokerit, Ozocerite	Hydrocarbon, methane series	White to brown	0·95–1	1	Am.	R.,D.	Candle mfr., beeswax substitute
PACHNOLITE	$Na,Ca,F_3.AlF_3.H_2O$	Colourless, white	2·97	3	V.	V.	
Paisbergite, *s.* Rhodonite							
Parasit, *s.* Boracite							
Parisite	$Ce(CeF)(CaF)(CO_3)_3$	Yellowish-white	4·36	4·5	III.	V.	In emerald mines
Patrinite, *s.* Aikinite							
Paulite, *s.* Hypersthene							
Peacock ore, *s.* Bornite							
Pectolite	$Na_2Ca_2(SiO_3)$	Whitish, greyish	2·73	5	V.	S., S.	A Hornblende variety
Peganite	$(OH_3.Al_2PO_4)_2.3H_2O$	Green, etc.	2·5	3·5	IV.	V., R.	
Periclase, Periclasite	MgO	Colourless to green	3·67	6	I.	Tp., Tc.	
Peridot, *v.* Olivine	$(Mg,Fe_2)SiO_4$	Pistachio-green	3·4	7	IV.	V.	Precious stone
Perlite	$K_2Al_2Si_9O_{20}.H_2O$	Grey	2·4	5	Am.	V.,P.	A felspar
Perofskite, Perovskite ..	$CaTiO_3$	Black, brown, etc.	4	5·5	I.	R.,A.	
Petalite	$(Li,Na.H)Al(Si_2O_5)_2$	Colourless, etc.	2·43	6·25	V.	V., P.	
Petroleum	Mixture of paraffins	Black, brown, etc.	0·6-0·9	—	—	—	A liquid saturating sandstones. Illumination, heat, power, gas mfr., lubricants, etc.
Petzite, *v.* Hessite	$(Ag,Au)_2Te$	Grey to black	9	2·75	IV. (?)	M.	Gold, silver
Phacolite, *s.* Chabazite							
Pharmacochalcite, *s* Olivenite							
Pharmacolite	$(Ca,Mg)_3(AsO_4)_3.6H_2O$	White	2·6	2·25	V.	V.,P.	
Pharmacosiderite	$Fe(FeOH)_3(AsO_4)_3.6H_2O$	Green, brown	3	2·75	I.	V.	Pyroelectric
Phenakite, Phenacite	Be_2SiO_4	Colourless, etc.	3	7·75	III.	V.	Precious stone
Phillipsite	$Al_2(Ca,Na_2,H_2)Si_6O_{16}.6H_2O$	White	2·2	5	V.	V.	
Phlogopite	$(Al,Fe)_2(Mg,Fe)_6(K,Na)_2(OH,F)_3Si_6O_{21}$	Brown, red	2·9	2·5	V.	P.	Mica group
Phosgenite	$(PbCl)_2CO_3$	White, yellow, green	6·2	3	II.	A. to R.	Lead
Phosphorochalcite	$(Cu,OH)_3PO_4$	Green	4·2	5	—	G. to V.	Pseudo-malachite
Phosphorite, *s.* Apatite							
Physalite, *s.* Pyrophysalite							
Picotite, *v.* Ceylonite.. ..	$(Mg,Fe)O(Al.Cr)_2O_3$	Yellowish-brown	4·08	8	I.	Tc.	Chrome spinel
Picrolite, *v.* Serpentine ..	$(Mg,Fe)_3H_4Si_2O_9$	Green, yellow	2·5	4	IV.	W. to E.	A greasy variety is amorphous
Pictite, *s.* Sphene							

* Odontolite is blue fossil-tooth, very similar to true Turquoise. *See* pages 5853, 5856.
† Oriental amethyst, emerald, and topaz are violet, green, and yellow sapphires, respectively.

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Piedmontite	$Ca_2(AlOH)(Mn,Al)_2.(SiO_4)_3$	Reddish	3·4	6·5	V.	V., P.	Epidote group
Pinguite, *v.* Chloropal ..	FeO,Fe_2O_3,SiO_2	Green	1	2·3	Mass.	V.	Very similar to [Chloropal
Pistacite, *s.* Epidote							
Pistomesite	$(Mg,Fe)CO_3$	Yellowish	4	4	III.	V.	
Pitchstone	$Na_2Al_2Si_{10}O_{24}.3H_2O$	Green, red, etc.	2·2	5	Am.	R.	A natural glass
Pitticite, Pittizite	$Fe_{20}(OH)_{24}(SO_4)_3.10AsPO_4.9H_2O$	Brown	2·3	3	Am.	V. to G	
Plaster of Paris (*see* Gypsum)							
Platinum	Pt, with Fe,Ir, Os, etc.	Steel-grey	17-19	5·75	I.	M.	Scientific and surgical instruments, jewellery, photography, etc.
Plattnerite	PbO_2	Iron-black	9·4	—	III.	M.,A.	
Plumbago, *s.* Graphite							
Plumboferrite	$Pb(Fe_2O_2)_3$	Black	—	5	Mass.	—	
Polianite	Mn_2O_4	Steel-grey	4·8	6	II.	M.	
Polyarsenite, *s.* Sarkinite							
Polybasite	$(Ag,Cu)_{18}(Sb,As)_2S_{12}$	Iron-black	6·2	2·5	IV.	M.	Silver (75 per cent.)
Polycrase	$(Ca,Fe)_4Y_4UO_2Ti_{12}O_{35}2[Y(NbO_3)_3]$	Black	5	5·5	IV.	V. to R.	Yttrium, titanium, uranium, niobium
Polyhalite	$Ca_2,Mg,K_2(SO_4)_4.2H_2O$	Red, grey	2·7	3	Fi.	V.,R.	
Polymignyte	$Ca_4(Ce,Fe)_4.Ca(NbO_3)_2.(Ti,Zr,Th)_{10}O_{29}$	Black	4·8	6·5	IV.	Sm.	Ce, Nb, Th
Porcelain earth, *s.* Kaolinite							
Potash alum, *s.* Kalinite							
Potstone, an impure Steatite							
Prehnite	$Al_2Ca_2H_2(SiO_4)_3$	Green	2·8	6·5	IV.	V.	
Prosopite	$Ca(F,OH)_2.2Al(F,OH)_3$	Colourless, white	2·88	4·5	V.	V.	
Proustite	Ag_3AsS_3	Red	5·42	2·75	III.	A.	Silver (65 per cent.)
Pseudomalachite, *s.* Phosphorochalcite							
Psilomelane	Mn manganate	Bluish-black	4	6·25	Am.	Sm.	Very variable; [manganese
Pucherite	$BiVO_4$	Brown, red	5·9	4	IV.	A.	
Pumice. *See* Obsidian							
Purple copper, *s.* Erubescite							
Pyrargyrite	Ag_3SbS_3	Black to red	5·8	3	III.	M.A.	Silver (59 per cent.) [sulphuric acid
Pyrgom, *s.* Fassaite							
Pyrites	FeS_2	Brass-yellow	5	6·5	I.	M.	Iron (46 per cent.),
Pyrolusite	MnO_2,H_2O	Black	4·8	2	IV.	M.	Common ore for Mn [and MnO_2
Pyromorphite	$Pb_5Cl(PO_4)_3$	Green, brown, etc.	6·5–7·1	3.5	III.	R.toV.	
Pyrope	$Mg_2Ca_3(SiO_4)_3$	Blood-red	3·7–3·8	7–7·5	I.	V.	Bohemian garnet (wrongly Cape ruby)
Pyrophyllite	$AlH.(SiO_3)_2$	White, green	2·8	1·5	IV.	P.	Similar to Agalmatolite
Pyrophysalite	Al_2F_2O,SiO_4	Yellowish-white	3·49	8	IV.	V.	Opaque topaz
Pyrostilpnite	Ag_3SbS_3	Red	4·25	2·5	V.	A.	Silver
Pyroxene, *s.* Augite							
Pyrrharsenite, *s.* Berzeliite							
Pyrrhotite, Pyrrhotine ..	$Fe_{11}S_{12}$	Bronze-yellow	4·5	4·5	III.	M.	Iron (60 per cent.), ferrous sulphate, sulphuric acid
QUARTZ (silica)	SiO_2	Colourless and all colours	2·7	7	III.	V.toG.	Most common rock-constituent; glass mfr., pottery, metallurgy, etc.
Quenstedtite	$Fe_2(SO_4)_3,(H_2O)$	Reddish-violet	2·1	2·5	V.	V.	
Quicksilver, *s.* Mercury							
RALSTONITE	$(Na_2Mg)F_2.3Al(F,OH)_3.2H_2O$	Colourless, milky	2·6	4·5	I.	V.	
Realgar	As_2S_2	Aurora red	3·5	2	V.	R. to A.	Arsenic ore (70 per cent.), pyrotechnics
Red lead ore, *s.* Crocoite							
Red ochre, *v.* Turgite	Fe_2O_3	Red	—	—	Am.	E.	Mixed with clay; [pigments
Redruthite, *s.* Copperglance							
Resinit, *s.* Pitchstone							
*Retinite							
Rhætizite, *s.* Cyanite							
Rhodochrosite	$(Mn,Ca,Fe,Mg)CO_3$	Rose-red	3–5	4·5	III.	V.,P.,R.	French Mn ore (47 per cent.)
Rhodonite	$MnSiO_3$	Rose-red	3·5	5·5	VI.	V., P.	Manganese spar; [Mn (41 per cent.)
Rhodophyllite, *s.* Kämmererite							
Riebeckite	$2NaFe(SiO_3)_2.FeSiO_3$	Black	—	—	V.	V.	Hornblende group; similar to Acmite
Riemannite, *s.* Allophane							
Ripidolite	$Al_3(Mg,Fe)_5H_9Si_3O_{20}$	Green	2·7	2·5	V.	P.	Transparent, dichroic
Rock crystal, *v.* Quartz ..	SiO_2	Colourless	2·7	7	III.	Tp.	Carved and cut into ornaments
Rock salt, *s.* salt							

* Retinite. A generic term for various amber-like fossil resins—*e.g.*, Copalite

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Römerite	$Fe_2(FeZn)(SO_4)_4.12H_2O$	Brown, yellow	2·17	3·25	VI.	V.	Pleochroic, transparent
Roscoelite	$KH_8(Mg,Fe)(Al,V)_4.12SiO_3$	Brown, greenish	2·93	—	—	P.	Found in small scales
Rose spar, *s.* Rhodocrosite							
Roselite	$(Ca,Co,Mg)_3(AsO_4)_2.2H_2O$	Rose-red	3·55	3·5	VI.	V.	Tp.; turns blue heated to 100°C.
Ruby, *v.* Corundum	Al_2O_3	Red	4	9	III.	V.	Precious stone, p. 5855
Rutile	Ti_2O_4	Red, brown	4	6·5	II.	A.	Resembles Cassiterite; porcelain painting, artificial teeth
SAHLITE, *v.* Pyroxene	$(Mg,Fe)Ca(SiO_3)_2$	Green	3·25–3·4	6	V.	V.	
Sal ammoniac	NH_4Cl	White, yellow	1·5	1·75	I.	G. to V.	Volcanic product; commercially artificial
Salmiak, *s.* Sal ammoniac							
Salt, common	$NaCl$	White	2·15	2·5	I.	V.	In stratified formations, arid regions, lakes and seas
Saltpetre, *s.* Nitre							
Samarskite	$(Fe,Y,Ce,Er)_4.(Nb_2O_7)_3,UO_2$	Velvet-black	5·7	5·5	IV.	V., R.	Cerium and yttrium metals
Sandbergerite, *s.* Tennantite							
Saponite	$(FeO,CaO,MgO)_6SiOAl_2O_3,Fe_2O_3,Si_2O_3,13H_2O$	White, yellow	2·2	1·5	Mass.	G.	Scotch igneous rocks
Sapphire, *v.* Corundum	Al_2O_3	Blue	4	9	III.	V.	Precious stone, p. 5855
Sarkinite	$Mn(Mn.OH)AsO_4$	Rose-red, yellow	4·18	4·5	V.	G.	
Sartorite	$PbAs_2S_4$	Lead grey	5·4	3	IV.	M.	
Sassolite, Sassoline	$B(OH)_3$	White, yellow	1·5	1·5	VI.	P.	Native boric acid
Scapolite	$Al_2(AlO)Ca_4(Si_2AlO_8)$	Grey, white	2·7	5·5	II.	G., V.	
Scheelite	$CaWO_4$	Brown, yellow	6	4·5	II.	R., A.	Tungsten ore (63 per cent.)
Schirmerite	$(Ag_2Pb)_3Bi_4S_9$	Grey, black	6·74	—	IV. (?)	M.	Silver
Schorl, Schörl, *v.* Tourmaline							
Schorlomite	$(Ca,Fe,Mg)(Fe,Ti)_2.3SiTiO_4$	Black	3·85	7·25	I.	V.	
Scleroclase, *s.* Sartorite							
Scolecite	$CaAl.Al(OH)_2.3SiO_3.2H_2O$	White, yellow, red	2·3	5·25	V.		Pyroelectric, transparent
Scorodite	$FeAsO_4.2H_2O$	Green, brown	3·2	4	IV.	V.	Arsenic
Seladonite, *s.* Celadonite							
Semeline, *s.* Spinthère							
Senarmontite	Sb_2O_3	White, grey	5·2	2·25	I.	A., R.	Antimony
Sepiolite, *s.* Meerschaum							
Serpentine	$H_4Mg_3Si_2O_9$	White	2·5	2–4	V.	R. to G.	Building-stone; finer varieties as marbles
Seybertite	$H_6(Mg,Ca,Fe)_{10}.Al_{10}Si_4O_{36}$	Brown, yellowish	3	4·5	V.	P., Sm.	Building-stone; finer varieties as marbles
Siderite	$FeCO_3$	Yellow, brown	3·8	4	III.	V., P.	Iron ore (48 per cent.)
Sideronatrite	$Na_2(Fe.OH)_2(SO_4)_3$	Yellow	2·25	2·25	V. (?)		
Silex, *s.* Quartz							
Sillimanite, *v.* Fibrolite	$Al(AlO)SiO_4$	Grey, brown	3·2	6·5	IV.	R., V.	Dimorphic with Cyanite
Silver	Ag	Silver-white	10·5	3	I.	M.	Occurs fibrous, massive or in films
Silver fahlerz, *s.* Freibergite							
Silverglance, *s.* Argentite							
Skutterudite	$CoAs_2$	Tin-white	6–7	5·75	I.	M.	Cobalt
Smaltite, Smaltine	$(Co,Fe,Ni)As_2$	Tin-white, grey	6·7–6·8	5	I.	M.	Cobalt ore
Smectite	$Al_2H_2(SiO_3)_4.xH_2O$	Grey	2	1	Am.	W.	Soapy feel
Smithsonite	$ZnCO_3$	White, greyish	4·2	4·5	III.	V., R.	Zinc ore (52 per cent.)
Soapstone, *s.* Steatite							
Sodalite	$Al_3(Al.Cl)Na_5(SiO_4)_4$	Blue, grey, etc.	2·1	5·5	I.	G., V.	
Soda alum, *s.* Mendozite							
Spathic iron, *s.* Siderite							
Specularite, *s.* Hæmatite							
Sperrylite	$(Pt,Rh)(As,Sb)_2$	Tin-white	10·6	6·5	I.	M.	Found with Ontario nickel ores
Spessartite, Spessartine	$Mn_2Fe_3(SiO_4)_3$	Hyacinth-red	4·0–4·3	7	I.	V.	A garnet
Sphalerite, *s.* Blende							
Sphene, *v.* Titanite	$CaSiTiO_5$	Yellow	3·5	6	V.	G.	Often translucent
Spinel	$Mg(AlO_2)_2$	Black, red, green, etc.	3·5–4·9	8	I.	V., R.	Precious stone, p. 5855
Spinthère, *v.* Sphene	$CaSiTiO_5$	Green	3·5	6	V.	V.	Often seed-like form
Spodumene	$Al(Li,Na)(SiO_3)_2$	Grey, white, green	3·1	6	V.	V.	Used in jewellery
Stannite, Stannine	$Cu_2FeS_nS_4$	Grey	4·4	3·5	I.	M.	Tin pyrites; tin (27 per cent.)
Stassfurtite, *s.* Boracite							
Staurolite	$(AlO)_4Fe(AlOH)(SiO_4)_2$	Brown	3·6	7·5	IV.	V.	
Steatite, *v.* Talc	$H_2Mg_3Si_4O_{12}$	Grey, green, etc.	2·7	1–2·5	IV., V.	V.	Firebrick, mantels, French chalk, polishes, carving, etc.
Stephanite	$Ag_{10}Sb_2S_4$	Grey	6·2	2·75	IV.	M.	Silver ore (68 per cent.)
Sternbergite	$AgFe_2S_3$	Brown, yellow	4·2	1·5	IV.	M.	Silver

Minerals.	Chemical formulæ or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Stibnite	Sb_2S_3	Lead-grey	4·5	2·5	IV.	M.	Common antimony ore (71 per cent.)
Stilbite	$(Ca,Na_2,K_2)Al_2Si_6O_{16}.6H_2O$	White	2·1	4	V.	V., S.	
Stilpnomelane	$2(Fe,Mg)O.Fe,Al_2O_3.5SiO_2.3H_2O$	Black	2·85	3·4	(?)	P., V., Sm.	
Stolzite	$PbWO_4$	Grey, brown	8	3	II.	R.	Tungsten
Strahlstein, *s.* Actinolite							
Stream tin ore, *s.* Cassiterite							
Striegisan, *s.* Wavellite							
Stromeyerite, Stromeyerine	$(Cu,Ag)_2S$	Iron-black	6·2	2·75	III.	M.	Silver (53 per cent.)
Strontianite	$(Sr,Ca)CO_3$	White, grey, etc.	3·7	4	I..	V., R.	
Struvite	$Mg(NH_4)PO_4.6H_2O$	Yellowish, brown	1·68	2	IV.	V.	Translucent; found in guano
Succinite, *s.* Amber	$C_{40}H_{64}O_4$	Yellow	1·05–1·09	2–2·5	Am.	R.	
Sulphur	S	Yellow, grey	2	2	IV.	A., R.	H_2SO_4, gunpowder, matches, bleaches, medicine
Sunstone, *v.* Oligoclase	$AlCaSi\cdot AlO_8$	Reddish-grey	2·65	6–7	VI.	V., P.	Jewellery
Sussexite	$(Mn,Mg,Zn)HBO_3$	Pinkish-white	3·42	3	IV.(?)	S. to P.	
Sylvanite	$(Ag,Au)Te_2$	Steel-grey	8·15	2	V.	M.	Au (24 per cent.), Ag (13 per cent.)
Sylvite, Sylvine	KCl	White, grey	2	2·5	I.	V., R.	Found in crater of Vesuvius and Stassfurt beds
TABULAR SPAR, *s.* Wollastonite							
Talc	$H_2Mg_3Si_4O_{12}$	White, green	2·7	1	V. (?)	P., G.	Paper weighting, soap, fire and waterproof paints, plasters
Tantalite	$Fe(TaO_3)_2$	Black	6·3	6	IV.	Sm.	Tantalum
Tellurite	TeO_2	White, yellow	5·9	2	IV.	Sm.	Tellurium
Tellurium	Te	Tin-white	6·2	2·5	III.	M.	
Tennantite	$Cu_8As_2S_7$	Steel-grey	4·7	3·5	I.	M.	Cu (50 per cent.); p h p. Ag to 14 per cent.
Tenorite, *v.* Melaconite	CuO	Grey, black	5·8	3·5	V.	M.	Copper; somewhat rare
Tephroite	Mn_2SiO_4	Grey, red	4·6	5·5	IV.	A., R.	
Tesselite, *s.* Apophyllite							
Tetradymite	$Bi_2(Te,S)_3$	Grey, white	7·2–7·9	2	III.	M.	Bismuth (59 per cent.)
Tetrahedrite	$(Cu_2,Ag_2,Fe,Zn)_4Sb_2S_7$	Grey, black	4·5–5·1	3·5	I	M.	Cu ([illegible]0 per cent.) Ag
Thenardite	Na_2SO_4	White to brownish	2·68	2·5	IV.	V.	On volcanic ashes
Thermonatrite	$Na_2CO_3.H_2O$	White to yellowish	1·55	1·25	IV.	V.	
Thomsonite	$2Al_2(Ca,Na_2)(SiO_4)_2.5H_2O$	White	2·3	5·5	IV.	V.	
Thorite	$ThSiO_4$	Orange, yellow, black	5·3	4·75	II.	V., R.	Thorium
Thorium sands, *s.* Monazite							
Thumite, *s.* Axinite							
Tiemannite	HgSe	Grey	7·2	2·75	I.	M.	Selenium
Tin	Sn	Tin-white	6·54	2·15	—	M.	Crystalline existence very doubtful
Tin pyrites, *s.* Stannite							
Tin stone, *s.* Cassiterite							
Tincal, *s.* Borax							
Titanite, *s.* Sphene	$CaSiTiO_5$	Brown, green, etc.	3·5	6	V.	G.	
Titanomorphite, *s.* Sphene							
Topaz	$2Al_2O_3.SiO_2SiF_2,H_2O$	Yellow, blue, white, red	3·5	8	IV.	V., A.	Precious stone, p. 5855
Topaz, oriental, *s.* Citrine							
Torberite, Torbernite, Cupro-uranite	$2UO_2.Cu(PO_4)_2.8H_2O$	Emerald-green	3·5	2	II.	P.	
Touchstone, *s.* Lydianstone							
Tourmaline	$Mg,Fe,Na_2Li_2,H_2,9AlO_2,Si_4B_2O_{20}$	All colours	2·9–3·3	7	III.	V.	Precious stone, p. 5855
Travertine, *s.* Calcite							
Tremolite (Hornblende group)	$Mg_3Ca(SiO_3)_4$	White, greenish-grey	3·2	6	V.	V., S.	Non-fibrous variety of Asbestos
Tridymite	SiO_2	Colourless to white	2·3	7	IV.	V.	
Tripe stone, *s.* Anhydrite							
Triphane, *s.* Spodumene							
Triphylite, Triphyline	$Li(Fe,Mn)PO_4$	Greenish, grey	3·6	4	IV.	R.	
Triplite	$(Fe,Mn)PO_4(Fe,Mn),F$	Brown, black	3·6–4	4·5	V.	R.	
Tripolite	Essentially SiO_2	White, greyish	1·9–2·3	5·5–6·5	Am.	E.	Is diatomaceous earth; polishes cement, boiler covering
Trona	$Na_2CO_3.NaHCO_3.2H_2O$	Grey, white	2·1	2·5–3	V.	V.	Tc.; near salt lakes, etc.
Tschermigite	$AlNH_4(SO_4)_2.12H_2O$	White	1·5	2·25	I.	V.	Native ammonia alum

Minerals.	Chemical formulae or composition.	Colour.	S.G.	H.	C.S.	Appearance.	Products, uses, or other remarks.
Turgite	$Fe_4O_5(OH)_2$	Reddish black to red	4·4	5·5	Am.	Sm.	Iron ore (65 per cent.)
Turquoise, Callaite ..	$Al_2(OH_3)PO_4.H_2O$	Blue, green	2·7	6	Mc.	Gl.	In jewellery, p. 5856
Tyrolite	$(CuOH)_4Cu(AsO_4)_2,7H_2O$	Blue to green	3	2·5	—	P.	
Tysonite	$(Ce,La,Di)F_3$	Yellow to brown	6·13	4·75	III.	V., R.	
UINTAHITE	Hydrocarbon	Black	1·08	2·25	Am.	B.	Varnishes, stove-blacking
Ulexite	$CaNaB_5O_9.6H_2O$	White	1·6	1	—	S.	
Ullmannite	$NiSbS.$	Tin-white	6·3	5·5	I.	M.	Nickel (27 per cent.)
Ultramarine, *s.* Lapis lazuli							
Uraninite	$(U,Pb_2)_3(UO_6)_2$	Black	6 4–8	5·5	I.	R.	Rare
Uranite *s.* Torberite							
Uranogumnite, *s.* Gummite							
Urao, *s.* Trona							
Urvölgyte, *s.* Herrengrundite							
Uvarovite .. .	$Ca_3Cr_2(SiO_4)_3$	Emerald-green	3·4–3.5	7 5	I.	V.	Calcium-chromium garnet
VALENTINITE	Sb_2O_3	White, grey	5·5	2 5	IV.	A	Antimony (83 per cent.)
Vanadinite	$Pb_3Cl(VO_4)_3$	Red, yellow, brown	7	3	III.	R	Similar to Endlichite
Vanadite, *s.* Descloizite							
Variscite	$AlPO_4.2H_2O$	Green to colourless	--	5	IV	V.	Variety of Callait
Vesuvian, *s.* of Idocrase							
Vitriol, *s.* Goslarite, *or*	Chalcanthite						
Vivianite	$Fe_3(PO_4)_2.8H_2O$	Blue, green, white	2·5	2 5	V.	V., P.	Transparent to translucent
Volborthite	$(Cu,Ca)(CuOH)VO_4$	Siskin-green	3 5	3	—	P., M.	
Volcanic glass, *s.* Pumice	—	—	—	—	—	—	*See* Obsidian
Volknerite, *s.* Hydrotalcite	—						
Vulpinite, *v.* Anhydrite ..	$CaSO_4,SiO_3$	—	—	—	—	—	Cut and polished for ornaments
WAD, bog manganese ..	$H_2Mn_2O_5$	Brown to blue-black	3·7	1	Am.	E., D.	Bleaching, umber paint
Wagnerite	Mg_2FPO_4	Yellow, white	3	5	V.	R.	
Warwickite	$Mg_6(Fe,Al,B)_6Ti_2O_{19}$	Bluish-black	3·35	3·5	IV.	Sm., P.	Pleochroic
Wavellite	$2(Al.OH)_3(PO_4)_2.9H_2O$	All colours	2·3	3	IV.	V., S.	
Wernerite, *s.* Scapolite							
White antimony, *s.* Valentinite							
White copperas, *s.* Coquimbite							
Willemite, Wilhelmite ..	$Zn·SiO_4$	White, grey, etc.	4	5·5	III.	V., R.	Zinc ore (60 per cent.)
Williamsite, *v.* Serpentine							
Witherite	$BaCO_3$	White, grey, yellow	4·2	4	IV.	V., R.	
Wittichenite, Wittichite ..	$(Cu_2)_3Bi_2S_6$	Grey, iron-black	5	2·75	IV.	M.	Bismuth (42 per cent.)
Wittingite, *s.* Neotocite							
Wolfram, Wolframite.. ..	$(Fe,Mn)WO_4$	Black	7·2	5	V.	Sm., A.	Tungsten (76 per cent.)
Wollastonite	$CaSiO_3$	White, grey, red	2 8	4·5	V.	V.	A veinstone
Wulfenite	$PbMoO_4$	Yellow, white,	6·5	3	II	A., V.	Molybdenum (26 per cent.)
Wurtzite	$(Zn,Fe)S$	Brown	4	4	III	A., P.	
XANTHOCONITE, Xanthocone	Ag_3AsS_4	Orange-yellow	5·1	2·5	III	A., P.	Silver
Xanthosiderite	$Fe_2O.(OH)_4$	Gold-yellow, brown	—	2 5	Fi	S., G.	In needles
Xenotime	$(Y,Ce)PO_4$	Yellowish, reddish	4·45	4·5	II.	R., V.	Yttrium, cerium
YENITE, *s.* Ilvaite							
Yttrocerite	$(Y,Er,Ce)F_3.(CaF)_5.H_2O$	Violet blue	3·45	4·5	—	V., P.	
Yttrotantalite	$Y(Nb,Ta)O_4$ & V,W,Er,Ce,Sn	Black, brown	5·7	5·25	IV.	Sm., V.	Opaque
ZARATITE	$2Ni(OH)_2NiCO_3.4H_2O$	Emerald-green	2 57	3·25	Am.	V.	Nickel (46 per cent.)
Zeagonite, *s.* Gismondite							
Zinc blende, *s.* Sphalerite							
Zinc spar, *s.* Calamine							
Zincite	$(Zn,Mn)O$	Orange-yellow	5·5	4	III.	Sm.	Zinc (80 per cent.); [New Jersey ore
Zinkenite	$PbSb_2S_4$	Lead-grey	5·3	2·5	IV	M.	
Zinnwaldite, *v.* Lepidolite ..	$(Li,K,Na)_4Al_3FeSi_5O_{16}(F,OH)_2$	Violet, yellow,	3	2·75	V.	P.	In layers of different colours
Zircon	$ZrSiO_4$	Colourless, and all colours	4·47	7·5	II.	A., R.	In jewellery. *See* p. 5855
Zirconite, *s.* Zircon							
Zoisite	$Al_2(Al.OH)Ca_2(SiO_4)_3$	Grey, red, e c.	3·2	6·5	IV.	V.	
Zunyite	$Al_8[Al(OH,FCl)_2]_6(SiO_4)_3$	Colourless	2·87	7	I.	V.	Clear and transparent

Group 7

LAW

Following THE CHURCHES from page 6607

THE LAW AS A CAREER

The Barrister. Examinations and Lectures. Success at the Bar.
The Solicitor. Commercial Law. Written and Verbal Contracts

THE term "lawyer" is used indiscriminately in England for the barrister and the solicitor.

Barristers differ from solicitors in their training, their functions, and their status. In no other country in the world, perhaps, is the distinction between the two branches of the profession so strongly marked. A wide chasm divides them. Of what the differences consist we shall learn in due course. At this point it will suffice to state that while the barrister is the advocate, the pleader, the man who voices the client's case outside (or inside) the bar of the court, the solicitors are the men of affairs who come in direct personal contact with the clients. In practice the barrister may only take his instructions from the solicitor, who is, so to speak, the steward or manager of the affairs of the lay client—*i.e.*, the member of the public who has need of legal assistance. The barrister may look to the solicitor alone for the payment of his professional fee, and, moreover, he has no right in law to recover it, except as money had and received by the solicitor on his (the barrister's) behalf. His services, in theory at least, are honorary; and for that reason, no doubt, many barristers where they have to deal with solicitors whom they regard with suspicion, refuse to go into court until payment is made in advance.

The Branches of the Profession. The young man who adopts law as a profession must make up his mind whether he means to choose the barrister or the solicitor branch; but otherwise there is no need to specialise until he is well over twenty-one. Whether a man means to be a barrister or a solicitor he cannot know too much about the things which have to do with the outside world. He will succeed best if he be a man of general information; the specialising in law will come later. Another word of warning may be given to the young man. Both professions—the Bar especially—are essentially "late-in-life" professions. The barrister must not hope to make a living wage before thirty, or riches—if he ever does make th m—before forty. The solicitor, unless he has a business of his own to fall into, must not be disheartened if he finds himself a managing clerk at thirty-seven. The would-be lawyer will have plenty of time to specialise in law when he is done with his general education. If he is fortunate enough to be able to go to a university, let him proceed patiently to his degree, whatever the subject he may choose. With this general preface we can proceed to deal with the two branches in detail.

THE BARRISTER

The first step to the Bar is to be enrolled as a student of one of the four Inns of Court. These are the Inner or Middle Temple, between the Strand and the Embankment; Lincoln's Inn, or Gray's Inn. Preliminary to admission, the young man must pass a qualifying examination consisting of elementary Latin and English dictation. He is, however, excused from this if he has passed a corresponding examination—*e.g.*, Responsions at Oxford [illegible] at one of the recognised universities. Once he is admitted a student he at once begins to specialise; and here, it may be remarked parenthetically, it will be lucky for him if his general knowledge includes the possession of one foreign language perfectly. In these days of universal education the barrister who is known to speak French or German will find himself in possession of an asset which may lead to a competence. Indeed, any specialty learnt in youth may prove the turning factor in victory to the middle-aged barrister. Even the possession of a hobby is enough to mark out a barrister from the "ruck," and (without illegal advertising) bring him into prominence and success. Some men have loved mechanics and scientific pursuits generally, have used their spare time from the law to follow out this bent, and have found it help them to a patent practice, than which the Bar offers nothing more remunerative. "Collect something, if only old violins," said a wise old Balliol tutor many years ago to the present writer, "and you will find that you will be known for that, and get on." But the advice must be followed with the utmost discretion. The young barrister who aspires to prominence by means of a hobby must do it in a blameless, ingenuous way.

The Barrister's "Dinners." The qualifying examination ended, the young man who desires to become a student must then be introduced by (or vouched for, as it amounts to) two barristers belonging to the Inn which he desires to join. These two members must sign a document, which stands as a reference for his respectability. He lodges £30 as security for his dinners in Hall, of which more later. He is now an admitted student and may proceed to "eat dinners." He must "eat" seventy-two dinners in all, or thirty-six if he is a member of a university. Not more than six dinners may be "eaten" in a term (three for members of a university). There are four terms in a year; accordingly the ceremony can be completed in three years at the shortest. Often men miss terms, with the result that it takes them four and five years to complete the required quota. And it is not an infrequent sight to see grey-haired students dining—men who began their terms thirty and forty years before, and are now finishing the requisite number after an interval of a career spent as Indian civil servants in India. The dinners are held in the halls of the various Inns. The dining terms are usually coincident with the middle portions of the legal terms.

Examinations and Lectures. While he is "eating" his dinners the student is able to turn his attention to the examinations which he must pass before he is able to proceed to his call. The Inns have joined together to supply the student with a very comprehensive series of lectures on the legal subjects in which he will be examined; and to encourage him to attend these lectures, the examinations are based directly upon the ground covered by the lecturers during the two years or so immediately preceding the date of the examination. But the syllabuses of these lectures are always to be purchased from the offices of the Council of Legal Education, Old Hall, Lincoln's Inn. Consequently, a student with any intelligence is well able to note

the ground covered without attending lectures. Where a student is reading for his degree up at Oxford or Cambridge he is quite unable to attend Bar lectures in London. If he is not at one of the universities it will pay him to attend the lectures assiduously. He will find the readers and lecturers appointed by the Inns of Court willing to help him, and there can be no doubt that he will shorten his labours very considerably. The subjects in which he will be required to pass a satisfactory test are given in the schedule on this page. They may be taken at different times, as will be seen from the appended form; and it may be said at once that the standard, though higher of late years, is not by any means a prohibitive one. Men are not "ploughed" in any great numbers; no doubt the theory being that any fairly intelligent man who desires to become a barrister should be allowed to do so. And then it resolves itself into a case of the survival of the fittest.

The Call to the Bar. When the student has passed all the examinations, and "eaten" his required number of dinners, he may proceed to his *call.* But certain preliminaries are still necessary. He must get a bencher of his Inn to propose him for call. There should be no difficulty about this. Some barrister of his acquaintance will be able to introduce him to a bencher. He must then pay £80 to his Inn, allowance being made for the £30 already lodged on account of battels, etc. That finishes the money part of his liabilities. His name is *screened* in Hall for a stated term before *call night.* "Call" nights come once in every dining term—that is, four times a year—viz., January, May, June and November. The ceremonies may differ a trifle in detail at each of the four Inns. At the Inner Temple, after dinner in Hall, the students about to be called are ushered into the "parliament chamber" or "common-room," where the benchers are drinking port and eating their dessert. The students are placed in a standing line along the walls of the room. Each one is given a glass of wine, and the benchers drink to them. The treasurer of the Inn, or the senior bencher present, makes them a little speech—generally telling them what a very difficult profession they have chosen. The senior student is then encouraged to make a suitable reply, and the ceremony ends. The young man has been *called* to the Bar, and is in a position to hold himself out for practice.

Technically, he may now consider himself a full-fledged barrister, but the custom of the profession has introduced a practice known as "reading in chambers." The young barrister, in return for a fee of £105, obtains the run of the chambers of some busy barrister for the space of one year. He has his desk in these chambers, reads all the briefs, draws pleadings, which his chief may or may not use according to their value, goes with his chief into court, and, in fact, "learns the ropes" of the profession which he has joined. There is no hard and fast rule about one year in one set of chambers, nor is it necessary for a man to wait to be called before he goes into chambers. He can enter while still a student and at any age the barrister with whom he reads may choose to take him. No man is eligible for *call* to the Bar under twenty-one, but anyone may become a student as soon as he can pass the qualifying examination for admission.

Again, as to the length of time in these chambers, many young barristers stay two years; others, again, stay six months in common law chambers, and six months in equity chambers—and try to find out in that way in which direction their bent or interest lies.

Specialising. Directly he has been "called," the young barrister has to make a very definite choice. He must make up his mind whether he will hold himself out for practice on the Chancery side, and become learned in conveyancing and trusts and partnership deeds and the like, or remain on the common law side of his profession, including anything from running down cases to libel and slander. He must make his choice advisedly, for, once started, he will find it exceedingly difficult to change over.

If the young practitioner elects to stay on the common law side, he will have to think of joining a circuit. Let him remember that this is a step to be taken early in his career. If he joins within a year of his "call" he will find no difficulty in his way. He must get a member of the circuit to propose him, he must dine three nights "on approval" at the circuit mess, and pay a matter of seven guineas as an entrance fee. Then his election will follow more or less as a matter of course. On the other hand, if he presents himself for election five or six years after his "call," he might find that the circuit refuses to elect him, on the theory that he has stood outside too long making up his mind which circuit to go, and therefore he may stand outside altogether.

The all-important question of chambers in town is another matter which concerns the young

SCHEDULE OF EXAMINATIONS FOR BARRISTERS

Examining Body and Grades.	Time and Place of Examination.	Subjects of Examinations.		Fees and Age Limits.
		Obligatory.	Alternative or Optional.	
THE INNS OF COURT	London		(For those who have not passed certain specified public examinations)	Not under 21
Preliminary ..	January May June November	Roman law, Constitutional law (English and Colonial) and Legal History Evidence Procedure, Civil and Criminal and Criminal law English law and Equity, including: (1) Law of Persons—Marriage and Divorce, Infancy, Lunacy, Corporations (2) Real and Personal Property and Conveyancing (3) Law of Obligations—Contracts, Torts, Estoppel, and Commercial law	Elementary Latin English Dictation	Included under total fee of £80 to the Inn

barrister. If he keeps to the common law he will elect to have his chambers in the Inner and Middle Temple; the equity man will set himself up in Lincoln's Inn or Gray's Inn. A good, small room, with the use of a clerk, can be obtained in any Inn for from £25 to £40 per annum, with a £5 minimum guarantee to the clerk; but the young practitioner cannot over-estimate the value of being in good and reputable chambers where there is plenty of bona fide work, even though he himself remains during the first years absolutely briefless. A good clerk who has his master's interests at heart helps i mensely towards final success.

Roads to Success. And now with our young barrister fully equipped, a member of a circuit, and settled in chambers in one of the Inns, the question that stares him in the face is "What chance has he of success?" There are two tests and two only, by which one may judge whether a man may succeed. First, "if a man can work when he has nothing to do"; second, "if a man can live and keep himself decent on nothing a year." Show me a man who can solve these two problems, and I will show you a future judge. In other words, the thing that kills most men, so far as the Bar is concerned, is the inability to keep alive their powers of application at a time when no solicitors want them. It is easy enough to get up at five o'clock in the morning and read briefs when you have got them to read; but the briefless junior who can get up at five o'clock and work hard is the man who will succeed. Naturally, the man with private means is in a better position to withstand the years of waiting, and that brings us to our second proposition, for names like Eldon and Herschell remind us that men have risen to the woolsack without a penny of their own. The secret of it has been their ability to live on nothing. Their absolute necessities they have supplied from teaching or writing for newspapers, but they have never let these avocations draw them away from the main object of their lives—the law. The work which brought them food and clothing was never allowed to invade the hours when they held themselves out for clients. What are the dangers of straying off the by-paths of law into literature only those know who have followed the will-o'-the-wisp of daily journalism. It is useless to deny that private means do away with the necessity of working at anything except the law. But there comes the danger of the young barrister throwing up his profession in disgust and spending his patrimony in a pleasanter and less arduous West End life.

"Devilling." Among the recognised roads to success is the practice of "devilling," or working at the briefs of a busy barrister who has far too much to do to read them himself. Many a man has thus come in contact with solicitors and succeeded to the practice of his "chief" when the latter "takes silk" or becomes a judge or a law officer of the Crown. But the "devil" must be a very good one, able to obtrude his personality quietly but firmly, and the "chief" must be a man of generous instincts, who does not keep his "Sydney Carton" rigorously in the background. Natures differ. Some barristers, with far more work than they can do in keeping with their duty to their clients, are willing to delegate it to the point of letting the "devil" have all the labour and none of the glory. They would not dream of letting their "devils" appear for them in court or come in contact with their clients. Happily, such men are few and far between. The majority of the profession are men with generous instincts, and the "devil" whose lot falls in fairly pleasant places will not only find plenty of work to do, but he will have the run of good chambers, and, into the bargain, be paid an honorarium for his trouble. Above all, he will have the pleasing feeling that he may step into his "chief's" practice, although, as a rule, when a busy junior leaves the outer Bar, his work generally becomes distributed among a number of other juniors left behind. But the "devil," if he is a man of any ability, will get some of it, and that will serve as a nucleus round which to build up a practice of his own.

Failure and Success. Failure at the Bar is a hard word, but it is a lot to be faced, and by very many. Of course, men drift away from the Bar into other employments. They become journalists and civil servants, and go into businesses (except solicitors' businesses, from which they are debarred). And if at forty they find themselves still hopelessly briefless, there always remains the West Coast of Africa—Lagos or Nigeria, or the Gold Coast! Other Colonial and foreign appointments are not numerous, and it must be stated that the briefless barrister without influence in high quarters need not hope for one. Unattractive as they may seem to ambitious twenty, utilitarian forty clusters after them. They range from Indian judgeships to West Indian law officers, and when one falls vacant there are about fifty applicants. The same may be said of the minor legal appointments in this country. County court judgeships are now eagerly sought after by "silks" in respectable practice. True, the emolument is only £1,500 a year, and the work hard and rather sordid. The same may be said of stipendiary magistracies, carrying £1,000 a year. A briefless junior, unless he had very influential friends, might just as well wish for the moon. To this extent, then, these minor appointments must yet be counted among the plums of the profession.

The High Court Bench. Of course, the biggest plums of the profession are puisne judgeships, lord-justiceships of Appeal, and law lordships. The salaries range from £5,000 to £7,000, the duties are responsible, and surrounded by a certain show of magnificence which makes them doubly attractive. No King's Counsel who has not a large practice need hope to be elevated to the bench unless he has made himself useful in political life by fighting for his party inside the House or out. If he is a Chancery judge, his work will always be in London; if a common law judge he may have to go on circuit four times a year, for which he receives ample travelling allowances and lodging money For the man who ends up a High Court judge, the Bar has, indeed, been a lucky speculation, but unfortunately few do.

THE SOLICITOR

The young man who decides to enter the lower branch of the legal profession must make up his mind to a longer term of pupilage, harder qualifying examinations, and possibly a position of lifelong subordination. On the other hand, he will earn a living wage much earlier in his career, while the mean level of pecuniary reward is certainly not less than that prevailing at the Bar.

The first step to become a solicitor is to pass a preliminary examination before entering into articles of clerkship to solicitors. Every man who wants to be a solicitor must first be an articled clerk—a species of apprentice to the practice of the law.

Examinations. First of all it may be mentioned that the examinations, and, indeed, all the official steps towards being enrolled, are conducted by the Law Society, Chancery Lane, London, W.C.,

the chartered company, so to speak, of the profession. And now to deal seriatim with the three examinations needed to qualify.

The Preliminary Examination is excused to certain candidates, as the following list shows.

EXEMPTIONS FROM PRELIMINARY EXAMINATIONS

Bachelors of Arts or Bachelors of Laws at the following Universities: Oxford, Cambridge, Dublin, Durham, London, Wales, Liverpool, Leeds, Royal University of Ireland, and Victoria University of Manchester; Bachelors of Arts, Masters of Arts, Bachelors of Laws, or Doctors of Law in any of the Universities of Scotland, none of such degrees being honorary.

Utter (junior) barristers in England.

Persons who have passed the following examinations:

First Public Examination before moderators at Oxford

Previous Examination at Cambridge.

Examination in arts for the second year at Durham.

Local Examination, Oxford (junior or senior).

Local (non-gremial) Examination, Cambridge (junior or senior).

Examination of the Oxford and Cambridge Schools Examination Board (higher certificate).

Matriculation Examination at Dublin or London (not necessarily in first division).

Examination for First-class Certificate of the College of Preceptors.

Provided the conditions set out below of the order of February 8th, 1905, be complied with, persons who have passed the following examinations are also exempt.

[(*a*) Latin shall be one of the subjects taken, and if Latin is not a compulsory subject the examination certificate shall state that the candidate has passed in Latin.

(*b*) All the subjects required to be taken by a candidate shall be taken at one examination, and the examination certificate shall state that they have been so taken.

(*c*) If any alteration be made in the regulations, character, or standard of an examination, this order shall immediately thereupon cease to apply to such examination]:

School-leaving Examination (Matriculation standard) of the University of London.

The examination of the Joint Matriculation Board of the Victoria University of Manchester, the University of Liverpool, and the University of Leeds.

The Matriculation or Entrance Examination of the University of Birmingham, and the School-leaving Examination (Senior Certificate) of that university.

The Matriculation Examination of the University of Wales.

The Examination for the Senior Certificate of the Central Welsh Board under the Welsh Intermediate Education Act, 1889.

The Responsions Examination at St. David's College, Lampeter.

The Local Examination of the University of Durham, Senior Pass Certificate, and the Junior Certificate, with at least second-class honours.

All persons who have obtained certificates of having passed the Preliminary Examination, or are exempt therefrom, may enter into articles of clerkship.

All persons exempted from the Preliminary Examination pay an additional £2 on giving notice for the Intermediate Examination (Judges' Order, June 28th, 1904).

For full particulars respecting this examination, the student is referred to schedule on this page.

No books will be previously specified for the language examinations, but passages will be given for translation at sight, with the assistance of a dictionary. Candidates must bring their own dictionaries.

Candidates are required to give, at least 30 days before the day appointed for the examination, notice to the Secretary of the Law Society of the *languages* in which they propose to be examined, the *town* at which they wish to be examined, and

SCHEDULE OF EXAMINATIONS FOR SOLICITORS

Examining Body and Grades.	Time and Place of Examination.	Subjects of Examinations. Obligatory.	Subjects of Examinations. Alternative or Optional.	Fees and Age Limits.
THE LAW SOCIETY	London and some of the principal towns.			Not under 21. For admission on the Roll of Solicitors.
Preliminary ..	February May July October	Dictation English Composition Mathematics: (*a*) Arithmetic; (*b*) Algebra, inclusive of simple equations and elementary; (c) Geometry as treated in Euclid I. to IV. Geography of Europe and History of England Latin—elementary	Any two of the following languages: Latin, ancient Greek, French, German, Spanish, Italian.	£4
Intermediate ..	January March June November	Elementary works on the laws of England. Elementary questions on accounts and bookkeeping	—	£6
Final	January March June October	Principles of the Law of Real and Personal Property, Conveyancing Procedure in all divisions of the High Court, Ecclesiastical and Criminal law, and practice and proceedings before Justices of the Peace	—	£10. £15 when Intermediate Examination is excused

their *age* and *residence*, and *place* or *mode of education*.

Articled Clerks. The Preliminary Examination satisfactorily disposed of, the young candidate may now enter into his *articles*.

The usual period for service under articles is five years, but for graduates of universities who are exempted from the Preliminary Examination, and for persons who have been called to the Bar, and are of less than five years' standing as barristers, the period is three years.

Persons who have passed the following examinations need serve only for four years:

First Public Examination before moderators at Oxford.

Previous Examination at Cambridge.

Examination in arts for the second year at Durham.

Entrance Examination at Dublin, having passed in honours.

Matriculation or Entrance Examination at London, Birmingham, or University of Wales, first division.

The Responsions Examination at St. David's College, Lampeter.

The Examination of the Joint Matriculation Board of the Victoria University of Manchester, University of Liverpool, and University of Leeds, first division.

Articled clerks bound for four or five years may serve one year with the London agent, and one year with a barrister or special pleader. Those bound for three years may serve one year with the London agent, but they cannot serve any part of the term with a barrister or special pleader.

The stamp duty on the articles is £80, and on further articles 10s.

Articles cannot be stamped after the date thereof, except on payment of penalties.

The articles must be enrolled and registered at the society's office within six months after execution. The fee payable to the society for registration is 5s.

When articles are left at the office of the Law Society for registration, a statutory declaration, impressed with a 2s. 6d. stamp, made by the attesting witness as to the due execution, must be produced, together with the certificate of having passed the Preliminary Examination or one of the examinations exempting from it. All certificates are returned with the articles.

The solicitor to whom the clerk is articled will also require a fee calculated on a basis of £300 for the whole five years.

The choice of a solicitor to whom to be articled will usually prove a more or less personal affair; but it is generally best for the clerk—like the youthful barrister—to go to the office, or chambers, where there is plenty of work to be had. He will gain experience more rapidly, see a greater variety of men and affairs, show his metal, and, if he is really a man of grit, be trusted with really responsible work.

Intermediate Examination. Every articled clerk, with certain exceptions, is required to pass the Intermediate Examination. He may present himself at any time after completing twelve months' service in his articles.

The subjects of the Intermediate Examination are such elementary works on the laws of England as the examination committee may from time to time appoint for that purpose, and elementary questions on accounts and bookkeeping.

The particular books selected for the examination are named in the month of July in the year previous to that for which they are selected.

If the candidate passes the examination he will receive a certificate to that effect; but in case he fails to do so he may, provided he has given the proper notice, attend any subsequent examination; but if he shall not have passed the examination before the expiration of twelve calendar months after the date when one-half of his term of service shall have expired, his final examination shall be postponed for so long a period as may intervene between the expiration of such last-mentioned twelve calendar months and his passing the examination, or for such shorter time as the examination committee shall direct. Should a candidate fail in accounts and bookkeeping only, he shall be allowed to come up again in those subjects without postponing his final examination, and if he passes in bookkeeping only he will not be required to come up again in that subject.

EXEMPTIONS FROM INTERMEDIATE EXAMINATION

All persons exempted from the Intermediate Examination in Stephen's Commentaries are required to pass in bookkeeping.

The following certificates are accepted in place of the Intermediate Examination: (1) A certificate of having before or after entering into articles passed the examination required for the degree of B.C.L. or LL.B. at one of the following universities in the United Kingdom—*viz.*, Oxford, Cambridge, London, Dublin, Durham, Wales, Birmingham, Liverpool, Leeds, or the Victoria University of Manchester; or (2) a certificate of having before entering into articles taken honours in the Final Honour School of Jurisprudence at Oxford or in the Law Tripos at Cambridge.

Candidates who are exempted from the Intermediate Examination in Stephen's Commentaries pay an additional fee of £5 on giving notice for their final examination, but no fee is payable by them for the examination in bookkeeping.

The fee payable on giving notice of examination is £6, and for a renewed notice £3.

Final Examination. The articled clerk has still one examination to pass. The subjects included, and other particulars, are given in schedule.

Candidates are required to give notice in writing *forty-two days* at least before the date of the examination to the Secretary of the Law Society, Chancery Lane, London.

Candidates are also required, *at the same time*, to leave with the secretary of the society their articles of clerkship and supplemental articles (if any), and certificate of having passed the Intermediate Examination, together with answers to the questions as to due service and conduct, to be answered by the candidate and his principal and agent, if any. Prints of these questions can be obtained on application at the office of the Law Society.

Notice of the desire of a candidate to compete for honours must be given when notice is given for final examination.

Admission to the Roll. It only remains to add the rules necessary to enable the qualified man to apply for admission on the roll of solicitors:

Notice for admission must be given to the Law Society six clear weeks *before* the first of the month in which such application is intended to be made; and such notice can be given before the applicant has passed the Final Examination.

No person can be admitted until he has attained twenty-one years of age, and until his term of service has expired.

If at the time of passing the Final Examination the term of service has not expired, further testimonials from the Principal will be required from the date of such examination to the expiration of the Articles; and where the candidate was under 21 years of age at the time of passing the examination, and has since attained that age, a letter from him to that effect will be required.

In order to avoid delay the Articles of Clerkship, the Final Examination Certificate, any further testimonials or letter required as above mentioned, and the Admission Certificate, impressed with the revenue stamp of £25, together with the fee of £5 payable to the Society, should be left at the office of the Society one week before the expiration of the six weeks.

The Admission Certificate will thereupon be sent to the Master of the Rolls for signature, and, when signed, the applicant's name will be entered on the Roll of Solicitors. The Notice for Admission will be received by post, but the Admission Certificate, after it has been signed, must be applied for at the office of the Society.

Admission cannot be ensured during vacation.

The Form of Notice may be obtained from most law stationers; and the Admission Certificate, with the stamp impressed, may be obtained from Somerset House.

So much, then, for the machinery The aspirant will see that it means many examinations, many years' pupilage, a good deal of hard money in fees and for "articles." During these years he must live, for he will get no salary. Consequently, it may be said with confidence that the man who desires to become a solicitor must be prepared to spend at least £1,000 before he can hope to be in a position to earn money at his profession. Now let us look at his chances of success.

The Chances of Success. It may be said at once that the young solicitor well recommended and with average intelligence may always be sure of a living wage. He may have to look about him for some time, but in the end he will run across some vacancy—a post in an office worth £200 a year, with the chances of rising to managing clerk at double the salary. Of course, the competition is a growing one, and the salaries show a proportionate tendency to diminish, but there is nothing like the penury and starvation to be faced by the barrister at the beginning of his career. There are also a number of official positions under Government, at home and abroad, for which solicitors alone are eligible, as well as municipal appointments—town clerks, clerks to borough councils, and the like. Of the former variety—carrying salaries from £400 to £1,000—it may be said that "influence" is the one thing needful. The young practitioner lacking influential friends must not hope to get a salaried post under Government, except perchance a legal post in West Africa, for which barristers and half-pay military officers are not forthcoming. Of the municipal appointments in the market, few go to any but solicitors of "standing." Carrying, as they do, salaries of £700 to £1,500, they are run after by men with practices, usually local practices.

The Varieties of Work. The young solicitor who means to fight his way through to a practice of his own may find it useful to consider the varieties of work comprised in his profession. These varieties are endless, and range from the City solicitor, with wealthy City firms and railway companies among his clients, to the police-court practitioner, whose advice is sought by the drunk and disorderly. Possibly the soundest basis of division is between litigation and non-litigous work. Many large firms have an abundance of both varieties. One department looks after the concerns of omnibus companies or railway companies, who are always being sued for damages for accidents; another department looks after the conveyancing needed by private clients. A will has to be made, a marriage settlement drawn up, a mortgage settled. Contracts are drafted in the solicitor's office, and any dubieties connected therewith which may lead to litigation come back to him to be dealt with. Company work is a very special and still remunerative branch, though to a certain extent the glory of this species of solicitor's business has departed. The solicitor whose name appears on the prospectus of a new issue not only charges a handsome fee for that, but the legal work in drafting the various documents required by law in the initiation of the company.

The Family Solicitor. The old family solicitor constitutes yet another variety. In his strong-boxes are all the deeds connected with the relations, pecuniary and otherwise, of clients, who place the utmost reliance in him. But he will be a wise man if he refuses to be made the repository of valuable scrip and money. That, so often, is the beginning of confusion and the loss of trust funds, which end in penal servitude for the solicitor. The proper place for securities is the bank; and solicitors are beginning to be more and more chary of allowing their offices to be used as banks.

COMMERCIAL LAW

In the course of his daily business there are certain fundamental principles of law which a man is required to know, for it must be remembered that ignorance is no excuse in law. True, in these days of complicated rights and special knowledge, there is always a solicitor to whom the business man may have immediate recourse, but it is possible for a good deal of mischief to be done before he is even aware that his business has brought him within a thousand miles of litigation. A letter may be written binding the sender to an arrangement the exact contrary to what he had intended; liabilities may have been incurred far beyond those anticipated by either of the parties. It is, then, the object of this article to supply a handy *vade mecum* which will prevent ineffaceable errors before the solicitor has come upon the scene; or, better still, to render the presence of a solicitor unnecessary. Without pretending to be exhaustive, the article will at least aim at being complete.

Reduced to its simplest elements, all business is a matter of buying and selling.

There are modifications of this primal basis, of course; but ultimately every man who goes down to his office day by day, either to work for himself or for his employer, goes down either to buy or to sell, generally to do both—to buy to sell again, or even to sell to buy back.

In England we have no code, unfortunately, but the law relating to the sale of personal property is to all effects codified by the *Sale of Goods Act*, 1893, which every business man should keep in his office. In it he will find much which he need not try to understand. But there are, on the other hand, certain sections which he will do well to get by heart. Thus in Section 3 it states that:

> *A contract of sale may be made in writing (either with or without seal), or by word of mouth, or partly in writing and partly by word of mouth, or may be implied by the conduct of the parties.*

Verbal Contracts. The business man who bears that in mind will never find himself pinned down to a bargain which he had never intended to make. So many men have an invincible conviction that they can never be bound to anything until they have set pen to paper, and had the result stamped at Somerset House. When once the

community has rid itself of this pleasing fiction, the law courts may close for lack of work. The section speaks for itself, and does not need comment. Enough to say here that signed and sealed documents play a very small part in fifty per cent. of the sales which take place daily. The fishmonger who sells a pound of salmon may or may not give a receipted bill to the customer; in any case, this document is nothing more than an evidence of the sale which has taken place without it, and is perfectly valid without it. On exchanges hundreds of thousands of pounds' worth of securities or commodities pass from seller to buyer by the medium of a single word, or even a nod. The contract note which follows is evidence of the same; but the bargain is perfectly good in law before the contract note has passed, and will be enforced.

A and B, who exchange informal letters agreeing on the one hand to buy and the other hand to sell, say, ten thousand tons of cement, are in contractual obligation to each other. Only, in all these bargains made by word of mouth or informal letters this single point is essential, both *parties must mean the same thing.*

Lawyers call it being "ad idem." Let us illustrate this doctrine by a concrete example. Smith writes to Jones. "Will you buy my house at Oxford as it stands?" Jones writes to Smith in reply: "Yes, I will buy your house. Of course, it is freehold?" If, as a matter of fact, Jones's assumption is wrong, and the house is not freehold, there then has never been a completed bargain between the parties. But even if Jones's assumption is right, it is arguable that there has as yet been no completed bargain on the letters, since Jones, instead of sending back an acceptance, sends an acceptance modified by another question.

Again, Robinson may say to Jackson, who is a coffee broker: "What can you do for me to-day?" Jackson merely answers: "Ten bags," to which Robinson merely nods and walks out. A dispute arises, and the courts will have to decide that particular transaction upon the custom of that particular trade, or, more likely, the habitual method of business between Robinson and Jackson. For there can be no doubt but that on the face of it there has been a contract.

Conditional Agreements. But supposing Jackson in reply to Robinson had said "Ten bags if cleared," and Robinson had nodded and gone out, the result would not have been a bargain, since Jackson's offer to sell was conditional upon a certain event, though in the event of the fulfilment of that condition the bargain becomes fixed. If, however, Jackson had merely said "Ten bags if I can," then there would have been no bargain at all.

Let us stop for a moment at the answer, "Ten bags if cleared." Here we have not a sale, but *a conditional agreement to sell,* for under the Sale of Goods Act, "where the transfer of the property in the goods is to take place at a future time or subject to some condition thereafter to be fulfilled, the contract is called an agreement to sell." And "an agreement to sell becomes a sale when the time elapses or the conditions are fulfilled subject to which the property in the goods is to be transferred."

In most cases bargains are struck by the medium of the pillar-box. The merchant in his office carries through most of his business by correspondence. Therefore it should be noted that the *acceptance of any offer becomes irrevocable when the letter containing any such acceptance has been posted.* The moment when the letter of acceptance is put in the public letter-box is the moment when the contract is complete. Evidence of such posting is evidence of completion. And the same rule applies to acceptance by telegram. Directly the telegram has been despatched the acceptance becomes irrevocable.

The Law and Private Pillar-boxes. In connection with acceptance by letter, a word may be said about private posting facilities which have sprung up in large institutions, such as offices and hotels, of late years. The Postmaster-General has allowed these buildings to be equipped with pillar-boxes, which, though within their private premises, are directly under the control of the postal authorities. They are cleared by the postmen of the district, who alone have the key. But proof of posting in them cannot be taken as evidence in a court of law as the completion of any bargain. Why, it is difficult to say. Possibly because the box is not situated in a public place.

In connection with the irrevocability of such acceptance by post, it may be useful to point out these three concise rules:

1. *An offer cannot be withdrawn after the acceptance has been duly posted.*

Thus A writes fully offering to sell a horse to B. The latter posts his acceptance, and in the meantime, before the acceptance reaches A, the latter has repented him of his original offer. It is too late to withdraw.

2. *The withdrawal of an offer must reach the other party before he has duly posted his acceptance.*

3. *An acceptance once posted cannot be revoked.*

There, then, we have in as few words as possible the main facts which a business man should know in his daily life so far as the acceptance of contracts is concerned. Let him disabuse his mind of the common belief of the ignorant that he is not bound to anything until his signature, properly witnessed by competent witnesses, has been affixed to the terms of the bargain, and the resulting document signed, sealed, and delivered. There is no magic in writing, nor in seals or stamps. True, the law has given validity to seals and stamps which it denies to verbal agreements, but there may be no seals, no stamps, no writing, and yet a perfectly valid and binding agreement.

Written Contracts. We come, then, in the conclusion of this branch of our subject, to *the need of writing* in the making of contracts. In other words, how far are contracts governed by *the Statute of Frauds,* that enactment passed in the reign of Charles II. (1677) which, with its undoubted salutary uses, has managed to create more confusion in the minds of subsequent citizens than any other single entry upon the statute book.

It is not necessary to repeat here the actual Section 17 of the Statute of Frauds, for it is in substance re-enacted in Section 4 of the Sale of Goods Act, which section runs as follows:

A contract for the sale of any goods of the value of ten pounds or upwards shall not be enforceable by action unless the buyer shall accept part of the goods so sold, and actually receive the same, or give something in earnest to bind the contract, or in part payment, or unless some note or memorandum in writing of the contract be made and signed by the party to be charged, or his agent in t at behalf.

The provisions of this section apply to every such contract, notwithstanding that the goods may be intended to be delivered at some future time, or may not at the time of such contract be actually made, procured, or provided, or fit or ready for delivery, or some act may be requisite for the making or

completing thereof, or rendering the same fit for delivery.

There is an acceptance of goods within the meaning of this section when the buyer does any act in relation to the goods which recognises a pre-existing contract of sale, whether there be an acceptance in performance of the contract or not.

The explanation of the sections given above would take up far more space than we have at our disposal. It will no doubt suffice to say here that they in no way conflict with what has already been said in this article as to the validity of sales made by word of mouth (parole evidence) or by actions (such as nodding at an auction, and the fall of the hammer), without words. The full significance of the Statute of Frauds may indeed be put in less than a dozen sentences. Its intention was to prevent the enforcement of verbal contracts above a certain value, unless the defendant could be shown to have executed the alleged contract by partial performance as manifested by part payment, or part acceptance, or unless his signature to some written note or memorandum of the bargain could be shown.

Thus a contract note referring to the sale of stocks and shares would be necessary to enforce an action to enforce completion, unless there had been partial delivery or some act which can be construed into partial performance. In such construction the custom of any particular trade or business may be called in aid—as, for instance, in stock exchange cases where the mode of business has been the same from time immemorial. But it must be remembered that the Statute of Frauds has no concern with written contracts which have been duly signed; for in those cases the common law affords sufficient guarantees against frauds and perjuries. In a word, the business man must remember that though his spoken word may lead him into an irrevocable bargain, the law requires certain *actions* as corroboration of the binding remarks uttered. Contracts duly signed and witnessed and stamped, will, in all cases where the business man who needs them is wise, be drawn up by a solicitor. Hence the legal requirements of such documents need not be considered further in this place.

Sample and Warranty. Another branch of the law of sale and purchase which affects the everyday life of the business man is the *quality of the thing sold.* Very often, and it cannot be otherwise, he finds himself face to face with this difficulty. He has bought goods on the word of the seller as to their quality, and then finds them inferior. The whole subject concerns the doctrines of *sample and warranty,* which can be dealt with shortly, so far as they give rise to questions which the business man may find that he has to deal with on the spot before he has time to get legal advice.

Upon this subject, then, the sections of the Sale of Goods Act are clear and precise:

Sect. 13.—Where there is a contract for the sale of goods by description, there is an implied condition that the goods shall correspond with the description; and if the sale be by sample, as well as by description, it is not sufficient that the bulk of the goods correspond with the sample if the goods do not also correspond with the description.

Sect. 14.—Subject to the provisions of this Act, and of any statute in that behalf, there is no implied warranty or condition as to the quality or fitness for any particular purpose of goods supplied under a contract of sale, except as follows:

(1) Where the buyer, expressly or by implication, makes known to the seller the particular purpose for which the goods are required, so as to show that the buyer relies on the seller's skill or judgment, and the goods are of a description which it is in the course of the seller's business to supply (whether he be the manufacturer or not), there is an implied condition that the goods shall be reasonably fit for such purpose, provided that in the case of a contract for the sale of a specified article under its patent or other trade name there is no implied condition as to its fitness for any particular purpose.

(2) Where goods are bought by description from a seller who deals in goods of that description (whether he be the manufacturer or not), there is an implied condition that the goods shall be of merchantable quality; provided that if the buyer has examined the goods, there shall be no implied condition as regards defects which such examination ought to have revealed.

(3) An implied warranty or condition as to quality or fitness for a particular purpose may be annexed by the usage of the trade.

Sect. 15.—(1) A contract of sale is a contract for sale by sample where there is a term in the contract expressed or implied to that effect.

(2) In the case of a contract for sale by sample:

(a) There is an implied condition that the bulk shall correspond with the sample in quality.

(b) There is an implied condition that the goods shall be free from any defect, rendering them unmerchantable, which would not be apparent on reasonable examination of the sample.

Sect. 33.—Where the seller of goods agrees to deliver them at his own risk at a place other than that where they are when sold the buyer must, nevertheless, unless otherwise agreed, take any risk of deterioration in the goods necessarily incident to the course of transit.

Transport of Goods. The concluding paragraph, which is sufficiently explicit, brings us to the consideration of the *transport of goods,* a wide and intricate subject which keeps the commercial court in London busy from year's end to year's end.

Section 20 of the Sale of Goods Act lays it down very clearly that:

Unless otherwise agreed, the goods remain at the seller's risk until the property therein is transferred to the buyer, but when the property therein is transferred to the buyer, the goods are at the buyer's risk whether the delivery has been made or not.

Provided that where delivery has been delayed through the fault of either buyer or seller, the goods are at the risk of the party in fault as regards any loss which might not have occurred but for such fault.

The business man may say that the above section is simple enough when someone has explained to him what is meant by the phrase "when the property therein is transferred." The answer is not so simple. The transference of the property may depend upon the conditions of the contract. Thus, the undertaking of a seller to ship a *complete* cargo on board steamship X—— at buyer's risk, would clearly in law be said to contemplate that the goods remain at seller's risk until they are all on board and *complete.* In truth, questions of this kind have vexed and will continue to vex lawyers, and laymen should leave them severely alone.

The rule of thumb which may guide the business man in such matters is this: Has he absolute controlling possession of the goods? If so, the responsibility is upon him, as seller or buyer, to see that they are not damaged in delivery, and his remedy is against the carriers for damage.

Continued

Group 20

WOOD-WORKING

8

Continued from page 6657

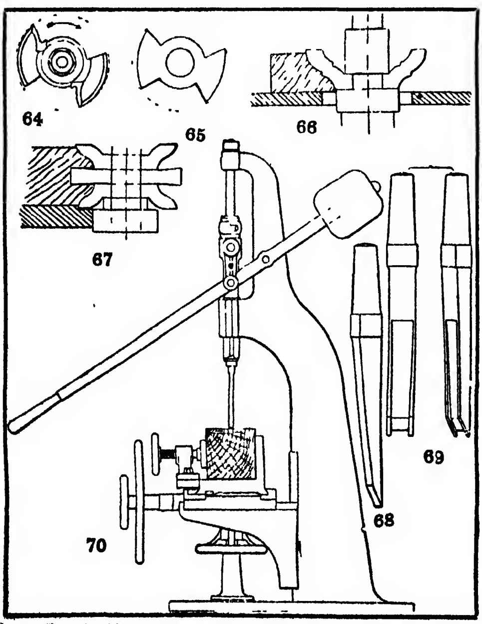
MISCELLANEOUS MACHINES

Varieties of Mortising Machines. Tenoning, Boring, and Dovetailing Machines. Special Lathes for Working Wood

By FRED HORNER

THE cutters and cutter-blocks employed in the planing and moulding machines described in the previous article embody numerous shapes, the simplest of which are those for plane surfaces, having flat knives bolted to the sides of a cylinder or block in the manner shown in **57** [page 4583], the length ranging from a few inches to two or three feet. Moulding cutters are also made as shown on that page. A very popular class of cutter-head for matching and moulding—the Shimer—differs radically in having a number of bits of circular form bolted around a circular head, the bits being set alternately so that each takes its share of the cut to right and left. The outline to be formed is imparted to the bits, which cut by one edge, produced by filing in a gap in the circle; the form remains unaltered until the bit is worn out.

The vertical spindle moulding machines use a variety of cutters. In the *French*, or slotted spindle a thin steel blade is fixed in a slot in the spindle end, and its edge being formed to correct outline, it is turned over forcibly like a scrape to produce a working edge. The French cutters are used chiefly for special classes of work, as the blades can be made cheaply and quickly. A common method is to fit flat cutters between grooved collars, as illustrated in **62** [page 6656]. Sometimes also an ordinary square block is fixed to the spindle end, to receive flat moulding cutters. Solid cutters bear some resemblance to milling cutters for metal, in having the moulded outline formed on the circumference.

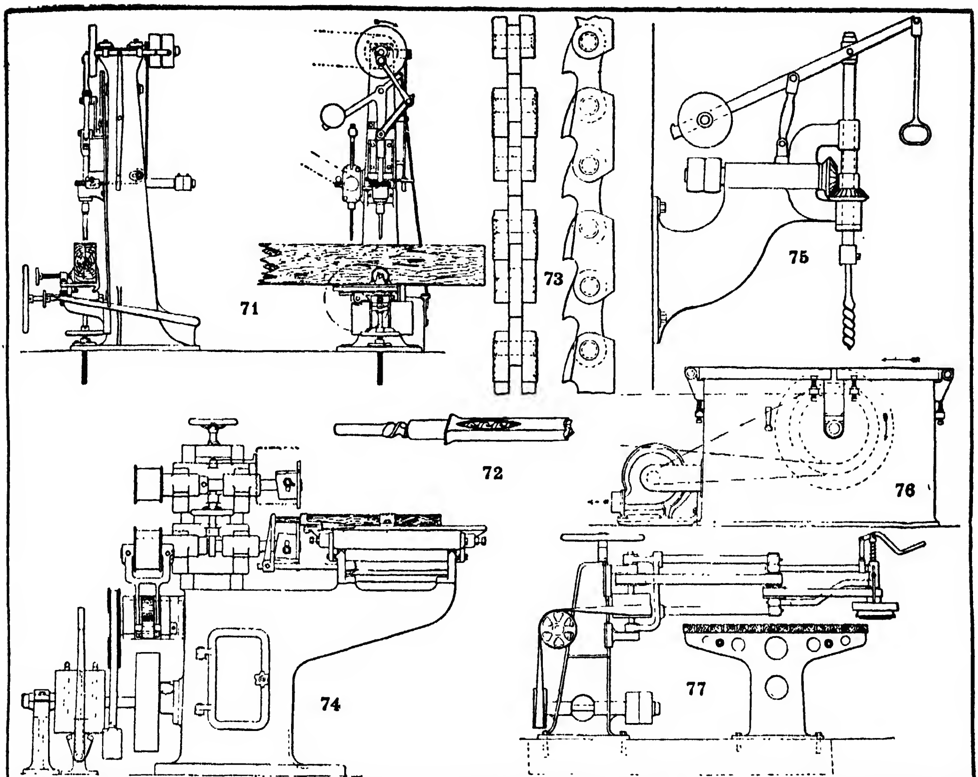


64-67. Moulding cutters **68 and 69.** Mortising chisels **70.** Hand mortising machine

Sharpening is done on the flat between the teeth. The non-reversible types have a clearance in one direction [**64**]; the reversible class are flatter on the periphery [**65**], so that either edge may come into operation as the machine spindle is reversed. Four, eight, or ten cutting edges are produced, according to whether the cutters have two, four, or five teeth [see **58**, page 4583]. Figures **66** and **67** illustrate their application, the first showing the use of the work itself to press against the guide collar under the cutter, the second that of a separate pattern plate to which the moulding is attached.

Mortising Machines. These, which are intended for cutting the slots or mortises in timber, are of vertical or horizontal types, the latter chiefly for light work. The commonest method is to use a chisel [**68**], resembling a hand mortising chisel, but held in a spindle, and fed down by hand or power. An improved form now in general use is the *self-coring* type [**69**], which has two projecting lips, which, being tapered inside, have the effect of drawing the chips from the mortise at each stroke, thus keeping the hole clear. Figure **70** shows a plain hand mortising machine, by the Carron Company, from which it will be seen that the timber is gripped in a vice by a handwheel and screw upon an upper slide which can be moved longitudinally by rack and handwheel, and also laterally, while vertical adjustment is produced by screw and handwheel beneath the knee. The spindle, which fits within a sleeve sliding in a hexagon bearing, is reciprocated up and down by the long pivoted lever, counterbalanced to bring the spindle to the top of its stroke automatically. A handle and collar is fitted on the spindle, by means of which it can be rapidly reversed, to make the chisel face round in the opposite direction for finishing both ends of a mortise. A boring attachment is often fitted to hand machines, for preparing holes ready for mortising; the attachment comprises a vertical spindle, carrying an auger, revolved through bevel gears and handle.

Figure **71** gives side and front elevations of a very complete mortiser by John McDowall & Sons, in which the boring spindle is a permanent fitting, set to one side, but in line with the mortising chisel, so that after boring a hole, the timber may be shifted longitudinally to bring it under the chisel stroke. The boring spindle is driven at 800 revolutions per minute by a belt on the small pulleys at the rear, and is fed downwards by pulling on a pivoted lever. The chisel spindle, guided in a circular bearing, is reciprocated by the crank disc at the top, making 300 revolutions a minute. The connection to the spindle is a graduated-stroke device, by means of which the stroke of the chisel is increased by stages, instead of descending the full length at once, with consequent jar. The effect is obtained by a peculiar arrangement of connecting levers, seen clearly in the front view, and brought into play by a treadle. In the normal state with the treadle at its highest, the chisel is stationary, although the



71. Combined mortising and boring machine 72. Hollow chisel 73. Mortising chain 74. Tenoning machine 75. Wall boring machine 76. Drum sand-papering machine 77. Flexible arm sand-papering machine

crank-disc is revolving, so that there is no necessity for stopping the latter frequently. A self-acting reversing motion is fitted to the chisel spindle, consisting of a cord driven down from the crank-disc shaft round an idler to a pulley on the spindle; the cord is put into action by touching a handle. In wheelwrights' shops a special attachment is fitted to the table of mortising machines, for cutting the mortises in wheel naves; the latter are held between two headstocks, one of which has a dividing plate, so that the mortises can be pitched out accurately around the periphery. The table is made to cant, in order to cut mortises at various angles.

A peculiar class of tool used for mortising comprises a combination of an auger and a chisel, the former revolving inside the latter, and clearing out the centre of the hole, while the square corners of the chisel finish the angles. This, the *hollow* chisel [72], is used in both vertical and horizontal machines, and is very rapid and neat in its action. The auger, which has a support near the cutting edges of the chisel, draws the chips out of the hole and away through the openings in the side of the chisel. Another remarkable style is the *chain* mortiser, which runs an endless pitch-chain around a sprocket wheel and a plain roller, while the back is supported by a flat bar. Each link of the chain has a tooth formed on it [73], so that as the chain travels it cuts a slot equal to its width. The rate of movement is about 1,500 ft. per minute. The chips are drawn out of the mortise on the rising side of the chain. The work is done with great rapidity, and the tendency to split the wood is not nearly so marked as is the case with a reciprocating tool.

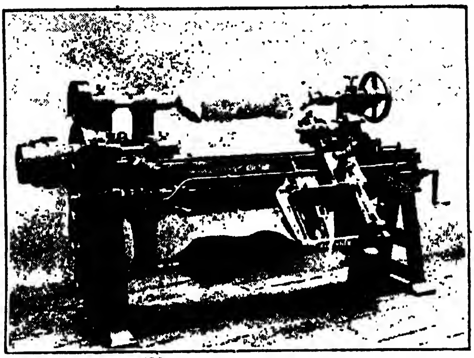
Tenoning Machines. Tenoning is performed by cutter blocks or by tenoning irons. The first-named operate laterally, and the machines which use them have two spindles, above and below the timber [74]—Thomas White & Sons—both driven from a single belt, which is provided with a tightening jockey pulley. The cutter or adze blocks have their irons set on the skew, and have provision for cutting the shoulders on the timber. The timber is clamped to a carriage which runs by rollers on cross-rails. In cutting double tenons, a vertical spindle is required on the machine, to carry a drunken saw, or a narrow cutter-block, which makes the centre cut. *Scribing*, or preparing a shoulder to receive a moulding may be also done with a vertical spindle, running a suitable block. Tenoning can be done on the vertical shapers, employing long-armed tenoning irons, drunken saws, or cutter-blocks.

Boring Machines. These are comparatively simple in construction. Spindles are single, or multiple; the plainest class is the wall or pillar machine [75], which consists of a framing supporting a spindle, a sleeve, mitre gears, belt pulleys, and a lever arrangement for feeding. The self-contained machines include a pillar, on the front face of which the table is adjustable up and down to suit the thickness of the work. The spindle is pulled down in a similar manner to that in 75. The multiple spindle machines embody a number of spindles, each holding a different-sized auger, so that any size hole within the range can be bored without the trouble of changing tools. The railway-carriage and waggon shops especially favour these machines for boring the heavy framings. In some instances, the spindles may

be angled for boring sloping holes. Horizontal boring machines are used to much less an extent than vertical ones, being chiefly designed for small work, such as bor'ng dowel holes in the edges of boards. The augers used in the machines described are of the usual twist types, some of which are illustrated in 41 on page 4481.

Dovetailing Machines. Dovetails are usually cut by revolving cutters, having two lips, and a body the form of which corresponds to the tapered outline of the dovetail. In the single-spindle machines the timber is clamped and moved along in definite stages, controlled by a slotted dividing plate matching the pitch of the dovetails. But a much greater output can be secured by increasing the number of spindles, to cut all the dovetails in one side of a board at one traverse. Armstrong's machine employs two saws, set at certain angles in relation to each other and to the board, which is clamped to a sliding table, fed intermittently. The work turned out on the machine is somewhat rough, though suitable enough for boxes and packing cases.

Corner locking is practised very largely in place of dovetailing, and consists in forming rectangular teeth which interlock and hold very firmly. As the form of cut lends itself to very rapid output, a good deal of box and case work is now corner-locked instead of dovetailed. The machines employed have a table on which the work, which may include a pile of boards, is clamped, and a revolving spindle holding a number of narrow cutters attacks the edges and cuts out the series of notches.



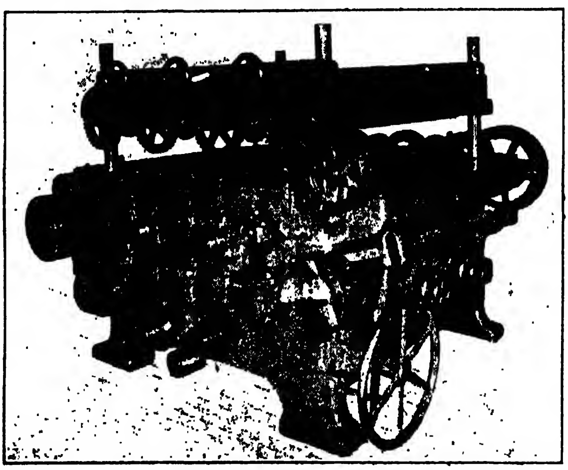
78. COPYING LATHE

Lathes. An ordinary turning lathe is illustrated in the succeeding article on Wood Turning, so that we shall only concern ourselves here with special types, which are designed for repetition work. The *Blanchard* or *copying* lathe produces objects of regular or irregular shape from a pattern or copy. Gun-stocks, spokes, hammer handles, boot lasts, brush handles, etc., are among the chief pieces turned out. The principle is that of rotating the copy, and the work, and causing a roller to press against the copy, thus coercing a rocking rest which carries a revolving cutter head in contact with the wood. The contour of the copy is therefore reproduced on the work. In 78, by Kirchner & Co., Leipzig, an excellent idea of the relation of copy and work, in this case the body of a toy horse, may be gained. The travel of the slide along the bed is effected by a screw operated through friction feed, and reversed automatically at the end of the traverse. The cutters are in the form of thin loops of steel, sharpened to a keen edge.

Back-knife lathes are a class for producing circular work of varied contour, such as chair and table legs, balusters, etc. The tools are held in a rest, and controlled by a pattern; the back knife is held in a frame in a sloping fashion, and the movements of the slide-rest and the knife are timed so that the latter comes down the back of the work and finishes it to correct outline as the roughing tool passes along.

The *rounding* machines perform a plain class of turning by very simple means, comprising a revolving mandrel carrying a cutter, which acts on the stuff, which is simply slid through.

Sand-papering Machines. These include the use of drums, discs, and belts, each suited to particular classes of work. The belts are run over pulleys, which can be drawn apart to give the required tension. Articles having curved outlines are treated on the belts, which give to the conformation and enable curves and hollows to be treated. The drum machines are of two types, one [76]—John McDowall & Sons—with a flat table, over which the work is passed, touching the drum surface. An exhaust fan removes the dust as fast as it is created. The other drum type has three drums, over which the wood is passed by eight geared feed rolls. Each drum has a side oscillating motion to prevent the formation of scratches. A machine by the J. A. Fay & Egan Co., of Cincinnati, O., is shown in 79. Small sanders with vertical spindles are constructed on the lines of the vertical shapers. Disc sanders resemble the disc grinders used by metal-workers, and the work is presented upon a table to the disc. For large areas the *flexible arm* machine is of great value. The sand-paper is strained over a wooden disc, supported at the end of an articulated frame, which, by virtue of its jointing, can be brought anywhere over a large table. The driving is effected by belts from pulleys on the standard to the left [77]—A. Ransome & Co., Ltd.—thence through the jointed portions to the pulley on the disc spindle. A handle allows the operator to feed the disc downwards



79. TRIPLE-DRUM SANDER

Continued

MANUFACTURING EXPLOSIVES

The Materials and Processes in the Manu'acture of Gunpowder, Nitro-glycerin, Dynam.te, Blas.ing Gelatin, Cordite, Ballistite, and Guncotton

Continued from page 6620

SINCE its inception until the present day the manufacture of explosives has been associated with the study of chemistry. Whoever may have been the genius that first applied the fireballs of the ancients to the propulsion of projectiles, there can be little, if any, doubt that these early experimenters were among the fore-runners of the modern chemist —the al-chemists. No definite date can be given for the invention of gunpowder, but the first references to its use as a propelling agent date from about the middle of the fourteenth century. From that time onward it spread throughout Europe with great rapidity, as the numerous references to it in early European literature show. Gunpowder at the beginning of the nineteenth century was essentially the same as when first invented. A few slight alterations in the proportions of the ingredients and a little more care in their purification covers the improvement effected. Inventive ingenuity seems to have turned in the direction of firearms, satisfied that the propelling agent was more than sufficient for the work it had to do.

It was not until the middle of the nineteenth century that the series of discoveries was made which revolutionised the explosives industry. In 1845 Sch nbein showed that cotton could be rendered explosive by treatment with nitric acid, and experiments by numerous other chemists soon reduced the discovery to a practical basis. The invention of nitro-cotton was followed in 1846 by the discovery of nitro-glycerin by the Italian chemist Sobrero, and Alfred Nobel, whose name is inseparably associated with high explosives, succeeded in overcoming the difficulties connected with the application of it to practical purposes.

The two essential discoveries on which the whole science of high explosives is founded are those of nitro-cotton and nitro-glycerin. The great majority of the explosives at present on the market under an infinity of names are mixtures in which the principal constituent is one or other of these substances.

Gunpowder. Black powder differs from nitro-cotton or nitro-glycerin in being a mechanical mixture, not a chemical compound. Its ingredients are simply intimately mixed together and are quite inert towards one another until the application of heat causes them to combine chemically, with formation of a mixture of gaseous compounds. It is this rapid chemical action or combustion which, owing to the great expansion due to the formation of gases, causes the explosion. The ingredients—sulphur, saltpetre, and charcoal—are mixed in the proportions which give fairly complete combustion, and, consequently, leave a very small amount of residue. Sulphur and charcoal are both combustible bodies, requiring only a sufficiency of oxygen with which to combine to convert them into gaseous compounds—the oxides of sulphur and carbon. Saltpetre, or potassium nitrate, is a salt rich in oxygen. Under the application of heat the oxygen in the saltpetre is transferred to the sulphur and carbon, with formation of gases. At the same time nitrogen, also a gaseous body, is liberated from the saltpetre, and other complicated changes take place which it is not necessary to detail here.

Saltpetre. Saltpetre is a natural product, found as a crust on the surface of the land in various parts of the world, notably in Bengal. The crude saltpetre is collected and its solution purified by crystallisation—that is, it is dissolved in water, freed from dirt and other insoluble matter, and evaporated by heat, so that the salt crystallises from the concentrated liquor in a purified form. The Government factory at Waltham Abbey, which may be used as a type of a modern explosives factory, refines its saltpetre as follows The vats in which the crude salt is dissolved are fitted with a perforated false bottom, through which solid impurities settle out. Heat is applied, and when the solution boils it is skimmed, and the false bottom, containing the dirt, is withdrawn. When all the scum has been removed, the solution is run through cloth filters into shallow pans, where the crystals separate. During crystallisation the liquor is kept in motion so that the crystals may be small. As they form they are withdrawn from the solution and drained. The crystals are then washed several times with water. The mother-liquors and wash-waters are, of course, worked up with subsequent batches of crude salt.

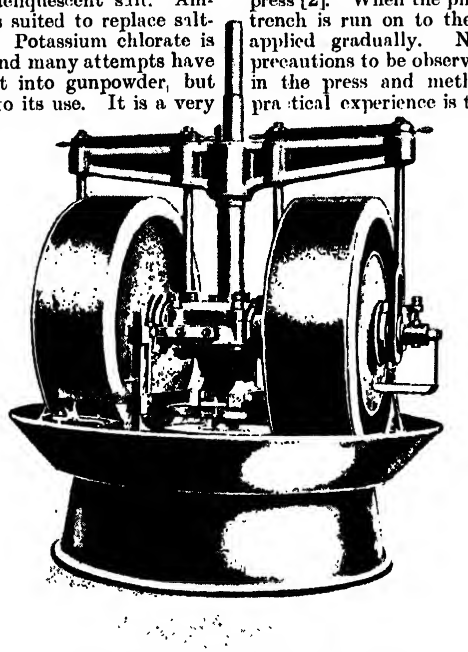
A large proportion of the saltpetre now used on the Continent is prepared artificially, from sodium nitrate or Chili saltpetre, and potassium chloride. These salts are both found native, and by double decomposition they may be converted into potassium nitrate (saltpetre) and sodium chloride (common salt). These salts are then separated from one another by crystallisation, which is rendered possible by their different degrees of solubility in water.

Sulphur. Sulphur, the second ingredient of black powder, is also obtained from the earth, large quantities coming from the numerous mines in Sicily. The crude ore is burnt in heaps, so that the sulphur melts and runs into a receptacle, from which it is drawn off and run into moulds. Before being incorporated into powder it has to be refined. The method in use at Waltham Abbey is substantially as follows. The crude sulphur is introduced into a still which can be closed by a cover. This is in connection with two receivers, one of which is used to collect the vapours before and after the actual distillation, the other to collect the purified sulphur. During the early part of the distillation the vapours are conducted to the former, where they cool in the form of flowers of sulphur. These are collected and re-distilled as crude sulphur. When the vapours from the retort change colour from yellow to purple, they are conducted to the second receiver, which is cooled by water, as is the pipe leading to it. The sulphur condenses in the pipe and runs into the receiver in liquid form. Another source of sulphur, which has come to the front only within recent years, is the Chance process for the recovery of sulphur from the waste-heaps of the soda factories. The sulphur obtained by this process is purified as described above.

Charcoal. Charcoal was formerly obtained by burning wood in large heaps in such a way that it was only partially consumed. This old and extravagant method is now entirely superseded. The wood is subjected to a destructive distillation in closed cylindrical vessels. At Waltham Abbey the plant consists of a large cylinder into which a number of smaller cylinders, charged with wood and closed, are packed. The large cylinder (which is built into a furnace) is heated, the wood is charred and the small cylinders, still closed, are removed while hot, and cooled before they are opened. In this way a great loss of charcoal, due to contact with the oxygen of the air while hot, is avoided. The charring of the wood is also easily regulated.

Within the past century many changes have naturally been suggested in the composition of gunpowder. The use of sodium nitrate as a substitute for potassium nitrate is found unsatisfactory, as the former is a very deliquescent salt. Ammonium nitrate is even less suited to replace saltpetre for the same reason. Potassium chlorate is a salt very rich in oxygen, and many attempts have been made to introduce it into gunpowder, but there are many objections to its use. It is a very dangerous salt to manufacture on account of its great oxidising power and sensitiveness to friction, and powders containing it evolve hydrochloric acid in the gun when fired. The introduction of charred straws to replace charcoal was an important advance, producing a slow-burning powder suitable for large guns, of high efficiency, especially when moulded in the prismatic form, which is described later.

The Grinding Mill. The sulphur, saltpetre, and charcoal are ground to fine powder separately in a grinding mill, which may be of almost any form. In early times the ingredients were mixed, and then ground and incorporated in one operation; but this plan was very unsatisfactory, as the mixture was never sufficiently intimate, and the danger of explosion from friction was much greater. The powdered ingredients are weighed out in the proportions desired, and mixed roughly in a copper drum by means of a revolving shaft fitted with forked arms. Great precautions are taken to prevent any foreign matter, such as scraps of iron, from getting into the charge.



1. INCORPORATING MILL (Fried. Krupp)

The roughly mixed charge—a "green charge," as it is called—is thoroughly mixed in an incorporating mill of the edge-runner type [1], the more modern of which have suspended runners, never actually touching the bed. The runners weigh about four tons, and the largest charge mixed at a time is 50 lb. to 60 lb., depending on the nature of the powder. The charge is spread upon the bed of the mill, and sufficient water added to prevent the material rising as dust, but not enough to cause the powder to cake on the runners. During the mixing, additional quantities of water are added as the early supply is evaporated. The mixing lasts from three hours to six hours, varying with the type of powder. A special drenching apparatus is fitted up, which pours water over the incorporating mill in the event of the ignition of the charge. When the mixing is completed, the powder is in the condition of mill-cake.

Breaking the Mill-cake. This mill-cake is broken to a convenient size by wooden hammers, and then passed through a breaking-down machine, which consists essentially of two pairs of brass rolls. The cake is roughly ground on the upper rolls, and falls through on to the second pair, where it is crushed to a fine powder. The pressing of this powder into a hard cake is now carried out, as a rule, by means of a hydraulic press. Alternate layers, consisting of powder and ebonite plates, are built on top of one another on a trench which runs upon the bed-plate of the press [2]. When the pile is of sufficient height, the trench is run on to the bed-plate, and pressure is applied gradually. Naturally, there are many precautions to be observed, and certain peculiarities in the press and method of manipulation; but practical experience is the best, and is, in fact, the only means of becoming acquainted with the details of the process. The pressure is continued for a time, averaging about half an hour. The trench is then withdrawn, and the edges of the cakes cut off, as they are not pressed to the same density as the body of the cake.

The cake has now to be transformed into the shape of grains. It is first broken to suitable size by means of wooden hammers, and then run through a breaking-down machine and sieved to size. The revolution of the disc breaks down the lumps of cake, which, when they are sufficiently small, fall through the perforations on to a second perforated tray with very small holes, through which the too finely pulverised portion is sifted off. This second sieve may be made of hair instead of being perforated, and the first sieve is often in the form of finely-meshed brass gauze. A number of these granulating sieves, with weighted discs, are connected together for economical working. By passing the grains through sieves of various-sized mesh, the powder may be sorted out into the sizes required for various purposes.

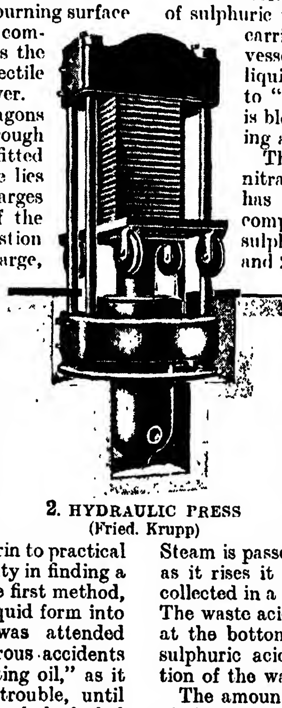
Glazing and Drying Gunpowder. The powder is glazed by being rotated in a drum for some hours, the time varying with the size of the granules. After this it is dried. The drying-room is a large chamber heated by steam, in which trays containing the powder are laid out in racks. The temperature employed varies from 100° to 140° F., and the powder takes from six to twelve hours to dry. When dry, the dust which is present among the grains is separated by rotating the powder for some hours in a closed cylindrical sieve, a small quantity of graphite being added to give a final gloss. The powder is again passed

through sieves of various sizes in a final sorting operation to separate the different sizes of grains. The powder is now finished, and requires only to be blended to be ready for use.

Composition of Gunpowder. The composition of gunpowder varies in different countries, and also in accordance with the purpose for which it is destined; but the most largely used formula, and the one most generally accepted, is: saltpetre, 75 parts; sulphur, 10 parts; charcoal, 15 parts. All other formulæ approximate closely to this.

In addition to ordinary rifle, sporting, and blasting powders, there are many varieties of gunpowder manufactured of which space does not permit description. Compressed powder is, however, of sufficient importance to receive some mention. The object of using compressed powder for large guns is to prevent too rapid combustion at the actual moment of firing. It is desired that the pressure in the gun should be small to begin with, and then rapidly increasing as the projectile nears the muzzle of the gun. By having the powder in blocks with holes through the centre of them—the so-called "prism powder"—a small burning surface is obtained, which increases as the combustion goes on; and as it increases the pressure grows greater, and the projectile is invested with greater carrying power.

Prism powder is made in regular hexagons with a number of holes running through them. These hexagons can be fitted accurately together so that no space lies between in any direction. Large charges are made up by fitting a number of the hexagons together, and the combustion takes place from the interior of the charge, thus giving the required increase in surface. It will readily be seen that did the burning begin on the outer surface, the burning area would be steadily decreasing instead of increasing. The prisms are made by hydraulic pressure, and the composition is practically identical with that of ordinary black powder, except in the case of cocoa, or brown powder, which consists of: potassium nitrate, 79; sulphur, 3; and charcoal, 18.



2. HYDRAULIC PRESS
(Fried. Krupp)

Nitro-glycerin. When Alfred Nobel attempted to adapt nitro-glycerin to practical purposes, he experienced great difficulty in finding a suitable form in which to use it. The first method, that of running the explosive in its liquid form into boreholes, and then exploding it, was attended with great danger, and many disastrous accidents occurred. The carriage of the "blasting oil," as it was called, was another source of trouble, until it was found that the solution in methyl alcohol greatly decreased the liability to explosion. The alcohol was evaporated immediately before the nitro-glycerin was required for use. Even then, however, the disadvantages of a liquid explosive were numerous, and it was not until Nobel succeeded in finding a suitable absorbent that nitro-glycerin became a success.

Nitro-glycerin is a chemical compound, formed by the action of nitric acid on ordinary glycerin. The glycerin used for the nitration is practically pure. It must contain only minute traces of mineral matter, and its ash should be below 0·10 per cent. It is prepared by the distillation of the crude glycerin from the soap and candle factories, and in some cases is purified in the explosive factory. Needless to say, the glycerin is thoroughly tested in the laboratory before being used on the manufacturing scale.

Ingredients in Nitro-glycerin. Although the active agent in the nitration of glycerin is nitric acid, in practice a mixture of nitric and sulphuric acids is used. When nitric acid acts on glycerin, nitro-glycerin and water are formed. As the action goes on the increasing quantity of water rapidly dilutes the nitric acid, with the result that the action slackens and side reactions are set up. To obviate this, some body is required which has an affinity for water, and which will absorb it as soon as it is formed. Strong sulphuric acid is found to be best suited for this purpose, as in the mixture with nitric acid it has no action on the nitro-glycerin. The nitric acid used is, as a rule, prepared in the factory where it is to be consumed, and in come cases sulphuric acid plant has been fitted up. The strongest acids are used, the nitric being of 1·5 specific gravity, and the sulphuric about 1·842. The proportions of the mixed acid vary in different factories, but on the average the mixture is about three-parts of sulphuric to two parts of nitric. The mixing is carried out in large wrought-iron cylindrical vessels supplied with air to agitate the liquids, and the acid is run from them to "moutejus," or "eggs," from which it is blown under high pressure to the nitrating apparatus.

The waste acid—that is, the acid after nitration, from which the nitro-glycerin has been completely separated—varies in composition, but averages 67 per cent. of sulphuric acid, 11 per cent. of nitric acid, and 22 per cent. of water. It is not found to be practicable to make up this waste acid to its original strength, and use it to nitrate a fresh charge of glycerin, so it is subjected to a process of denitration. Various methods are used to separate and recover the acids, and of these the following has been widely adopted. The waste acid, freed from nitro-glycerin, is allowed to percolate from top to bottom of a tower, various devices being made use of to expose as large a surface of the liquid as possible. Steam is passed in at the bottom of the tower, and as it rises it carries away the nitric acid, which is collected in a dilute state in earthenware receivers. The waste acid, freed from nitric acid, is collected at the bottom of the tower, and consists of dilute sulphuric acid, which is concentrated by evaporation of the water from it.

The amount of acid required to nitrate one part of glycerin varies in different works, but is usually from seven to eight parts, and the yield of nitro-glycerin is from 200 per cent. to 220 per cent. of the glycerin used.

Nitrating Apparatus. The first operation in the actual manufacture is the nitration. For convenience of working, the whole plant is arranged so that at the conclusion of each operation the nitro-glycerin may flow downwards to the building in which the next stage is carried out. Thus, the nitrating house is, if possible, situated at the summit of a small hill. If such be not available, the buildings are arranged artificially one above another. In any case the plant is usually known as a "hill." The nitrating apparatus [3] consists of a large lead-lined tank, in the interior of

which are a number of lead coils, through which cold water flows during the nitration, the object being to keep the temperature down. At the bottom of the tank is a perforated lead pipe, for the admission of air, to keep the contents in a continual state of movement. A lead cover is fitted over the tank, perforated with a small hole through which the thermometer bulb passes down into the acid, and with a large hole connected with a pipe to carry off the acid fumes to a condensing apparatus. Several thick glass windows, L, circular in shape, are inserted in the cover, so that the contents of the tank may be observed. There is an inlet pipe for the mixed acid, and another for the glycerin, the latter being sometimes sprayed in by means of an air-jet. At the bottom of the tank is an outlet pipe through which the charge is run off when the nitration is finished. During the nitration the outlet pipe is invariably in connection with a large tank of water called the " drowning tank," so that in the event of any abnormality in the nitration the whole charge may be drowned by the turning of a cock.

Working the Nitrating Apparatus. The mixed acid is weighed out and run into the nitrating apparatus. When the man in charge is satisfied that everything is in order, he turns on the air pressure so that the acid is kept in continual movement. Meanwhile, the weighed quantity of glycerin (from 700 lb. to 900 lb.) has been run into a small tank M, at some height above the nitrator, and connected to it by a pipe. In winter it is necessary to have the glycerin slightly warmed, so that it will pass readily through the injector. The glycerin is now added in a thin stream, the man in charge of the operation keeping his attention continually fixed on the scale of the thermometer, where a red line at the figure 22° C. denotes the point above which the mercury must not be allowed to rise. In Germany and other Continental countries nitration is carried out at from 25° C. to 30° C., but in Great Britain 22° C is the usual limit. By regulating the flow of glycerin, and the supply of water to the coils, the temperature can be maintained constant to a degree during the nitration.

The Separating Tank. When the whole of the glycerin has been added, the charge is allowed to remain in the nitrator until the temperature falls to about 17° C. The outlet pipe is then disconnected from the drowning tank, and connected to the separating tank in the building below—the separating house—and the whole charge run into this tank. The separating tank varies in construction according to the method of separation used. In this country the nitro-glycerin is usually skimmed by hand, and the tank is a lead-lined rectangular apparatus whose bottom slopes towards one end, where the outlet pipe is situated. In this tank the charge remains until the nitro-glycerin has all risen to the top. This takes from 1½ to 2½ hours. The nitro-glycerin is skimmed off by means of an aluminium skimmer, shaped like a soup-plate with a handle over the top. As it is skimmed it is poured into a sloping trough, from which it runs through a lead pipe to the tank in which it receives its first washing, to remove the greater part of the acid from it—the " pre-wash tank." When all the nitro-glycerin has been removed by skimming as far as possible, the charge of waste acid is run out of the separating tank and conducted to a large building filled with lead vats. These are filled up with the waste acid and the latter allowed to rest for some days so that the last of the nitro-glycerin may rise to the top. The vats, which are wide at the base, taper at the neck, so that the small quantity of nitro-glycerin may be readily skimmed off with a dipping ladle, or this process of after separation may be obviated by the addition of small quantities of water to the waste acid, which prevents further formation of nitro-glycerin, and permits of immediate denitration of the acid (patent, Nathan, etc.).

Meanwhile, the main body of the nitro-glycerin, which has been skimmed in the separating house, is subjected to a preliminary washing with dilute sodium carbonate in a tank situated in the separating house.

Washing Nitro-glycerin. The nitro-glycerin is now run out of the pre-wash tank through a series of pipes or covered gutters (the latter being often preferred, as they are more easily cleaned in case of stoppage) to the wash-tank in the washing-house. The wash-house contains large tanks each capable of washing about a ton of nitro-glycerin. At the back of this building is a small shed in which the solutions of soda are made up and heated by steam. The sodium carbonate solution and hot water are run into the washing-tank and mixed by air pressure with the nitro-glycerin, the temperature of the whole not exceeding 30° C.

After fifteen minutes' agitation with the soda, the air supply is shut off, and the soda rises to the top. A few minutes are allowed for the separation of the soda, and it is then skimmed off, or run off by means of rubber tubes situated at different levels in the tank, so that the top layer may be completely removed without loss of nitro-glycerin. The washings with soda are repeated three or more times until purification is complete. In early work with nitro-glycerin many of the serious accidents were due to the presence of traces of acid in the explosive. Slight decompositions set in and the nitro-glycerin gradually became very unstable.

To free the nitro-glycerin from sodium carbonate, one or more water washes are given after the soda has been drawn off.

The Process of Filtering. As a rule, the nitro-glycerin is weighed off in the washing-house. From the wash tanks it is run into a reservoir tank through a filter, which renders it clear in colour, removing the minute particles of water with which it is mixed. The filter consists of a cloth filled with dry common salt or sponges. Below the reservoir tank stands a weighing machine, or measuring vessels may be used to avoid this. Boxes are brought in containing the weighed quantities of the other ingredients of the explosives. These are placed upon the weighing machine, tared carefully, and the requisite amount of nitro-glycerin weighed in. The boxes are then removed from the platform of the machine, and the nitro-glycerin mixed roughly with the solid ingredients by hand. This obviates the difficulty of conveying the nitro-glycerin from place to place in the liquid state, a proceeding which is fraught with some danger.

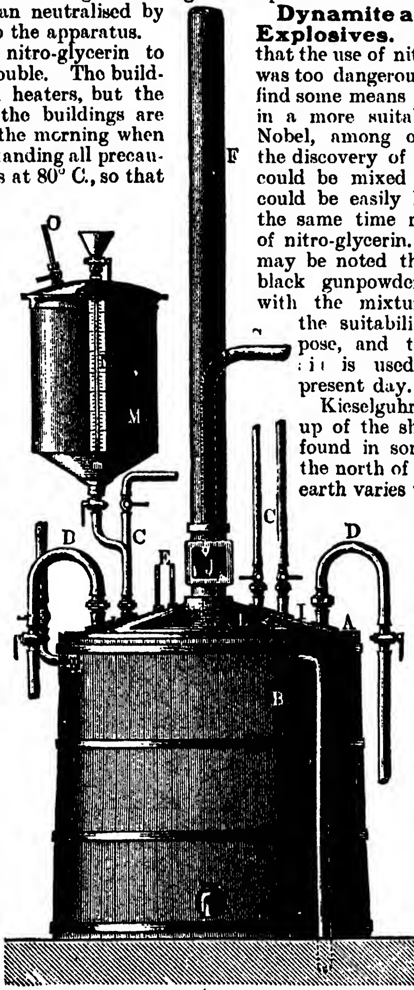
Throughout the whole of the operations described above great precautions are taken to avoid all chances of explosion. The clothes of the men engaged in the manufacture are made specially for them, and are without any metal buttons. Pockets are also forbidden, so that there may be no temptation to bring unauthorised articles into the danger area. At the door of each building rubber shoes are put on over the boots, so that no grit from outside may be brought into the buildings. The Government and factory regulations are posted prominently in every building, and they are read over to the men by their foreman at frequent intervals.

Dangers of Nitro-glycerin. Of all explosives, nitro-glycerin is the most dangerous to handle and manufacture. It will readily be seen that a liquid is less easily removed entirely when the vessels containing it have to be cleaned out. In the case of a spill, also, it is extremely difficult to clean up the last traces. At one time, the floors of all buildings in which nitro-glycerin was used were composed of fine sand, which was frequently changed; but the advantages accruing from this plan were more than neutralised by the danger of grit getting into the apparatus.

In winter, the liability of nitro-glycerin to freeze is a source of much trouble. The buildings are kept heated by steam heaters, but the pipes and gutters connecting the buildings are very apt to be frozen up in the morning when work is due to begin, notwithstanding all precautions. Nitro-glycerin solidifies at 80° C., so that in even moderately cold weather this trouble occurs. Unfortunately, also, in the solid state, it is much more dangerous to handle. Thus, the mere fracturing of a crystal has been known to cause explosion. Strangely enough, if proper precautions are taken, nitro-glycerin may be cooled far below its ordinary freezing-point without becoming solid; but the least shaking of the liquid, or the addition of a small crystal of solid nitro-glycerin is sufficient to cause it to solidify suddenly. This is the phenomenon of super-cooling. The only safe method of thawing nitro-glycerin is by means of warm water, but this will be referred to in detail later.

Medicinal Use of Nitro-glycerin. Nitro-glycerin has a very strong action on the heart, and is used medicinally in infinitesimal doses in cases of *angina pectoris.* The novice, on entering a building where the manufacture is being carried on, is seized with a violent throbbing of the head which develops into a bad headache, lasting throughout the remainder of the day. In bad cases, sickness, with violent vomiting, occurs. These symptoms are most marked when the explosive comes into contact with the skin, as it is absorbed through the pores and thus enters the system. In a few weeks most of the workers become quite inured to nitro-glycerin, and though their arms may be soaked in it above the elbow, they suffer no ill effects. Should they be away for a week or two, however, on returning to work they are again subject to headaches. There seems to be no permanent ill effect to the workers, as they appear as healthy as workers employed in any other class of labour.

When pure, nitro-glycerin is colourless, but the commercial variety is generally slightly yellow. It is without smell, and has a sweetish taste. It is soluble in benzene, ether, alcohol, and other organic solvents, but insoluble in water. A drop of nitro-glycerin explodes when struck with a hammer on an anvil. When the liquid is heated in any quantity, it explodes at about 180° C., though very small quantities have been raised to much higher temperatures without detonating. Of course, combined heating at much lower temperatures (below 100° C.) gradually decomposes nitro-glycerin, and it explodes with violence.



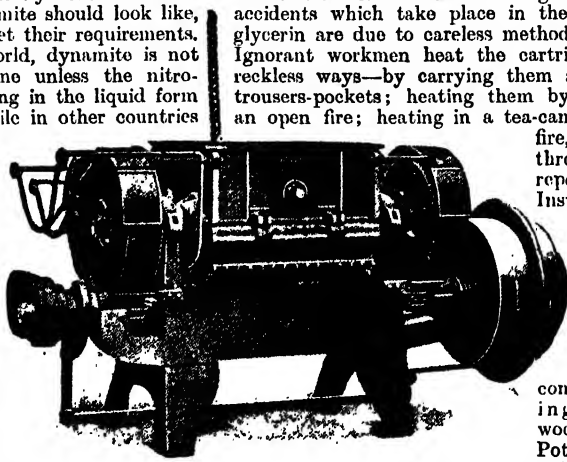
3. NITRATING PLANT (From Guttmann's "Explosives")
A. Lead vessel B. Wooden vat C. Air inlet pipes D. Cooling worms E. Thermometers F. Fume pipe G. Inlet pipe for acids I. Cover J. Sight glass K. Earthenware tap L. Glass panes M. Wrot iron cylinder N. Gauge glass and scale O. Pipe for admitting compressed air

Dynamite and Other Nitro-glycerin Explosives. As stated above, it was found that the use of nitro-glycerin in the liquid state was too dangerous, and it became necessary to find some means whereby it could be obtained in a more suitable form. The attention of Nobel, among other investigators, turned to the discovery of some substance with which it could be mixed to give a plastic mass which could be easily handled, and which would at the same time retain the explosive properties of nitro-glycerin. Amongst the early attempts may be noted that of mixing the liquid with black gunpowder and filling the cartridges with the mixture. Alfred Noble discovered the suitability of kieselguhr for the purpose, and the explosive made with its aid is used in large quantities to the present day.

Kieselguhr is an infusorial earth, made up of the shells of minute diatoms. It is found in some parts of Germany, and in the north of Scotland, near Aberdeen. The earth varies very much in appearance, that found in Germany being almost pure white, while Scotch "guhr" is dark grey, almost black. As found in nature, kieselguhr contains a large proportion of organic matter, which has to be burnt off before the earth is used. It may either be piled in heaps and burned — which process takes some days—or roasted in furnaces. When calcined in this way, kieselguhr is usually of a salmon-pink colour, and very light and impalpable. Under the microscope it is seen to consist of innumerable minute structures of many different shapes. The source of the guhr may often be told by an examination of the structures. The latter are hollow or tubular, and are capable of absorbing a large quantity of nitro-glycerin. Dynamite usually contains 25 parts of guhr to 75 parts of nitro-glycerin, and is only sufficiently moist to adhere when pressed.

Preparing Dynamite. Dynamite is prepared almost entirely by hand. The kieselguhr, after it has been calcined, is ground in a mill, and then weighed out in suitable quantities. Considerable care has to be taken with the grinding. It is necessary to break the calcined lumps to powder, but if the milling be carried on over long, the structures of the shells will be broken down and the absorptive power of the guhr greatly decreased. Thus, samples calcined and mixed with nitro-

glycerin in the laboratory show an absorption greater by several points per cent. than the same guhr calcined and ground on the larger scale. The weighed quantities of guhr are placed in large wooden boxes with brass fittings, and conveyed on trucks to the wash-house where the nitro-glycerin is stored. The necessary amount of the latter is weighed in and the box removed from the weighing machine to a bench, where a workman, with sleeves rolled up to the shoulder, roughly mixes the ingredients with his hands. This rough mixing is given in order that the nitro-glycerin may not be lying in pools in the box during its conveyance from the wash-house to the mixing-house. The boxes are again placed on a truck, and taken to the mixing-house, where the dynamite is thoroughly mixed. A small quantity (usually about ½ per cent.) of sodium carbonate is added, and uniformity of composition is obtained by repeated rubbing by hand through brass sieves. The consistence of the dynamite is of great importance. As it is mostly used by miners, who have their own ideas—mostly without foundation—as to what good dynamite should look like, it has to be prepared to meet their requirements. Thus, in our part of the world, dynamite is not thought worthy of the name unless the nitro-glycerin may be seen exuding in the liquid form on the cartridge paper; while in other countries an exudation such as this is considered a proof of inferiority. The manufacturer must consider these prejudices, and bear in mind the destination of a batch while it is being made, so that he may regulate the proportions. As a matter of fact, the slight difference in proportion required to change the dynamite from dry to damp will make little if any difference on its explosive power.



4. EXPLOSIVE MIXING MACHINE
(Werner, Pfleiderer & Perkins, Ltd.)

Making Dynamite Cartridges. When mixed and sieved, dynamite is a chocolate-coloured, soft, mealy material, and is ready to be pressed into cartridges. This operation is generally carried out in a machine worked by hand. A funnel-shaped cavity tapers at the bottom into a brass tube the diameter of the cartridge which it is desired to make. A plunger with a brass, or preferably a hard wood, head, works up and down in the funnel, pressing the dynamite with which the latter is filled through the tube. The plunger is worked by a lever handle at right angles to it. The handle is pressed down, carrying the plunger down through the funnel, and by means of a spring it rises ready for the next stroke. The operator rolls a cartridge paper round the tube at the bottom of the funnel, folds in the ends, and presses down the lever several times until the paper is filled. The cartridge is then removed from the machine, the upper end of the paper folded in, and the operation is finished. A considerable amount of practice is required in order to know just how much pressure to apply with each stroke of the plunger. Too great pressure forces the dynamite into a solid lump and causes the nitro-glycerin to exude on to the cartridge paper.

The earlier forms of this machine were very unsatisfactory. The loose dynamite worked its way into the joints of the machine, and in the course of time a bearing heated, or a sharp tap of metal on metal caused the explosive to fire. Immediately the whole stock in the building flared up and the occupants were lucky if they escaped with their lives. So many modifications and improvements have been introduced that the machine is now almost entirely without danger to the operator. As a rule, several cartridge machines are fitted to the walls of a small wooden hut, which is isolated—as are all explosive buildings—by high banks of earth or sand.

Disadvantages of Dynamite. The great disadvantage of dynamite in practical use is its liability to freeze in winter. When frozen, it is as hard as stone, and an attempt to insert a detonator into the cartridge would be not only difficult, but highly dangerous. Consequently, dynamite must always be thawed in winter before use, and the only safe method of thawing it is to place the cartridge in a warming-pan, which is a water-jacketed pan, within the double walls of which water at 60° C. is contained. A great many of the accidents which take place in the use of nitro-glycerin are due to careless methods of thawing. Ignorant workmen heat the cartridges in many reckless ways—by carrying them about in their trousers-pockets; heating them by placing near an open fire; heating in a tea-can over an open fire, etc. A glance through the annual report of the Chief Inspector of Explosives would furnish many such instances.

There are many modifications of dynamite on the market, containing such ingredients as wood-pulp, etc. Potassium nitrate, sodium nitrate, ammonium oxalate, and other salts are incorporated with other modifications, each being used to gain some special advantage for the explosive.

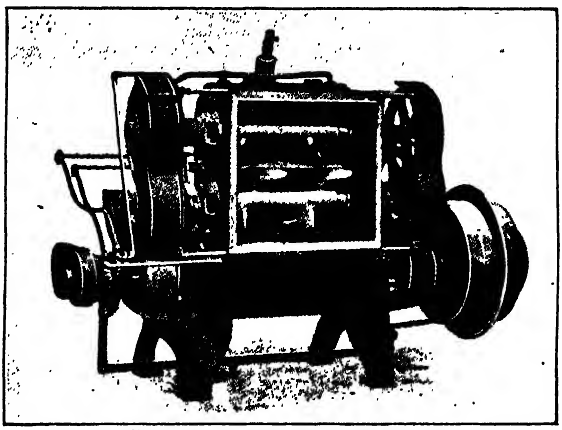
Blasting Gelatin. The invention, by Nobel, of blasting gelatin greatly reduced the consumption of dynamite. He found that by mixing nitro-glycerin with collodion cotton, a weakly nitrated cotton soluble in ether alcohol, and heating the mixture, a homogeneous gelatinous mass was obtained, which possessed great advantages over any existing explosive. Roughly speaking, the proportions of the mixture are about 90 parts nitro-glycerin to 10 parts of nitro-cotton, but the quantities vary with different makers. The nitro-glycerin is added to the nitro-cotton in the wash-house, and mixed there roughly, as mentioned above. The mixture is conveyed to the gelatin house, where it is heated in a copper or brass pan, by means of a water-jacket, to a temperature of about 45°—50° C. The pan is fitted with stirrers which keep the mass in movement. Specially modified Werner and Pfleiderer mixers [4 and 5] are generally used. A batch of blasting gelatin is mixed and gelatinised in about an hour.

The solid gelatinised mass is cut into smaller lumps and carried to the cartridge-making huts, which differ from the dynamite huts in the cartridge

machines used. The machine is practically an ordinary sausage machine. It consists essentially of a spiral working within a cover. The gelatin is placed in a small hopper and the first coil of the spiral catches it and carries it along towards the nozzle, from which it appears in the form of a long continuous sausage. The whole machine is made of brass, and the spiral is actuated by a shaft turned by hand. Nozzles of different sizes can be fitted to the machine, according to the size of the cartridge desired. The continuous gelatin sausage is cut into suitable lengths by means of a wooden hinge, the lengths are rolled in paper, and the cartridges are ready to be packed.

There are many modifications of blasting gelatin, just as there are of dynamite. The method of manufacture is, however, essentially the same. The best known of these are gelatin-dynamite and gelignite, the former being a blasting gelatin containing a certain proportion of wood-pulp, and the latter containing wood-pulp and potassium nitrate. These ingredients are incorporated with the explosive during gelatination. Other gelatin explosives are manufactured, containing ammonium oxalate.

Cordite. Cordite, which was patented by Sir F. A. Nobel and Professor Dewar, is also a gelatinised mixture of nitrated cotton and nitro-glycerin; but in this case the cotton used is guncotton, the most highly nitrated cotton. The mixture cannot be gelatinised simply by dissolving the guncotton in nitro-glycerin, as it is not soluble. Consequently, some medium is required to render the gelatinisation possible, and for this purpose acetone is used. The guncotton and nitro-glycerin are mixed together in the required proportions (cordite as originally used consisted of 58 per cent. of nitro-glycerin, 37 per cent. guncotton, and 5 per cent. vaseline), and acetone is added and hardened into the mass. To this, after about 3½ hours mixing, the correct amount of vaseline is added, and the whole mixed for 3½ hours more in a Werner and Pfleiderer mixing machine. When the mixture is thoroughly gelatinised, it is removed to the press-house to be formed into the cords in which it is used. For this, hydraulic pressure is required, and special presses have been designed to meet the requirements. The soft gelatin is placed in a steel cylinder and pressed by a tightly-fitting plunger through a hole situated at the other end of the cylinder. As the cords are pressed out, they are rolled upon reels and removed to a drying-house where the acetone is evaporated. Large sizes of cordite are not reeled up, but are cut to the required length at once and dried in trays. The temperature at which drying is carried out is about 100° F. Recently, the composition of cordite has been altered, and the new explosive is known as "Modified Cordite." The process of manufacture is, however, essentially the same.



5. EXPLOSIVE MIXING MACHINE
(Showing trough tilted)

Ballistite. Another smokeless powder similar to cordite in some respects is *ballistite*, the invention of Alfred Nobel. It is composed of 50 per cent. of soluble nitro-cotton and 50 per cent. of nitro-glycerin. In this case the soluble cotton will not dissolve directly in the nitro-glycerin, as it does in the case of blasting gelatin, as the proportion of nitro-cotton is too great. Consequently, a solvent is used as with cordite, in this case, benzene. In many respects the process of manufacture is similar to that of cordite, but the form of the finished explosive is different. The gelatinised mass is pressed through heated rolls and emerges in the form of a thin sheet, which is cut up by another machine into small squares.

Nitro-cotton. The principle of the manufacture of nitro-cotton is the same as that of the manufacture of nitro-gylcerin—namely, the treatment of the substance to be nitrated with strong nitric acid. Here, also, a mixture of nitric and sulphuric acids is used, with the object of removing the excess of water formed. The cotton used is received in the explosive factory in large compressed bales. It is the waste from the cotton mills. Before it can be nitrated it must be subjected to a preliminary purification to free it from dirt, grit, oily matter, etc., and to get it into a suitable state of division for nitration. It is then placed in stoves and dried at about 100° C., being withdrawn from the stoves and weighed just when required for use.

The great difference between the nitration of glycerin and cotton lies in the fact that the former, on treatment with nitric acid, always — with one exception—gives the same product—tri-nitro-glycerin; whereas cotton gives a whole series of nitro-derivatives according to the constitution of the acid mixture. Guncotton is the compound in which the greatest amount of nitration has taken place, six molecules of nitric acid being combined with two molecules of cotton. Other nitro-cottons have been isolated, containing five, four, three, and two nitro groups. Soluble cotton or collodion cotton is a mixture of these lower nitrated cottons. It is used in the manufacture of blasting gelatin, and also in many other industries. Nitro-cotton of a very low degree of nitration is used for the manufacture of articles of the celluloid class. When very slightly nitrated, its liability to explosion is slight, though it is still highly inflammable. In the following description of the method of manufacture we shall consider guncotton, the most highly nitrated cotton, to be the variety under treatment.

The mixed acid used is prepared as described under Nitro-glycerin. It consists, on an average, of one part of nitric acid to three parts of sulphuric acid, both being highly concentrated. A very large excess of mixed acid is required, compared to that actually taken up by the cotton. As a result, the waste acid is still fairly strong, and is made up to its former

composition by adding more strong acid, and used again for another batch of cotton.

Manufacturing Guncotton. As a typical example of the manufacture of guncotton, the main lines of the method employed at Waltham Abbey may be followed, although it must be remembered that each factory has its own peculiarities. The years that have been spent on the investigation of nitro-cotton have produced much information, a great deal of which has never reached beyond the works in which it originated.

Quantities of dried cotton of about 1¼ lb. weight are dipped into a tank or "dipping-pot" containing a large excess of mixed acid. The mass is removed with a large pronged fork as soon as it is soaked with acid, and placed in small earthenware jars shaped like ordinary pails and having earthenware covers. The cotton soaks up about eleven times its own weight of acid in the dipping-pot, and is allowed to retain it in the earthenware jar for about twenty-four hours. A large number of these jars are placed on a tiled floor or pit, a little lower in level than the surrounding floor, so that water may circulate round the jars and keep the temperature down. Even with this precaution there is some danger of the acid cotton "fuming off." One of the jars may become overheated, and rapid decomposition takes place, with liberation of great volumes of brown fumes. The decomposition spreads to other jars, and unless the area affected is isolated at once, decomposition may become general. The men in charge immediately remove the pots in the neighbourhood, and allow those which have fumed off to die down. No explosion takes place, the only danger being from the fumes which are generated and affect the lungs.

Treatment After Nitration. When the nitration is completed, the contents of the jars are emptied into a centrifugal machine, the basket of which is made of finely perforated wrought iron. The transference from the nitrating jars to the centrifugal is as rapid as possible, as it is desirable that the nitro-cotton should not be in contact with the air while it contains a large proportion of acid. Even while in the centrifugal, fuming-off or firing is not at all uncommon. When the basket is charged with acid cotton, the centrifugal is set in motion and the excess of acid is forced out through the perforations. When this operation is completed, the nitro-cotton is removed as quickly as possible from the basket and put under water in a wash tank. Fresh water flows through the tank, loss of nitro-cotton being prevented by a sieve over the outlet pipe. The continuous changing of the water, and the agitation and pressing caused by the paddle-wheel, remove the excess of acid from the cotton. When it is at last neutral to litmus paper the excess of water is removed in a centrifugal machine. Although the nitro-cotton after this preliminary washing is apparently free from acid, it has been found that this is far from being the case. In the early days of nitro-explosives numerous decompositions accompanied by explosion took place when guncotton was stored for any length of time. Sir Frederick Abel was the first to point out the reason of this. The fibres of the cotton are hollow, and at the end of the nitration are filled with acid. It was found that no amount of washing was sufficient to remove this acid completely, and until Sir Frederick Abel proposed the disintegration of the fibre, nitro-cotton was a highly dangerous body in practice.

Before pulping, however, the guncotton is boiled for some time in large wooden vats. The vats are filled with guncotton and water, steam is passed in from below, and the boiling continued for a varying time, as much as three to four days being sometimes given.

Purifying and Drying Guncotton. As mentioned above, it is necessary to destroy the tubes of the cotton fibres before the purification can be complete. This is done in the pulping machine [6]. A revolving drum, the circumference of which is fitted with knives, rotates in a trough. At one part of its course is a set of closely-set knives, between which and the knives of the drum the guncotton is crushed and cut. The trough contains a quantity of guncotton in water, and as the drum rotates it carries part of the guncotton round to the fixed set of knives. The space between the rotating knives and the fixed set can be regulated, so that it is comparatively large towards the beginning of the pulping, and is decreased as the operation goes on. The water in the trough may be changed continually as in the preliminary washing, or the pulping may be carried out with one water, and the pulped cotton washed afterwards with repeated quantities of warm water. When the pulping and washing are finished, the guncotton should be perfectly free from acid. Samples are drawn from it, and the "heat test" is applied. The guncotton must now stand the test for the regulation time. The excess of water is removed by again centrifugalising or by a moulding machine, this time a flannel cloth or bag being placed inside the basket of the machine, as the guncotton is in such a fine state of division that ordinary perforations would not keep it back. If not required for immediate use, guncotton is usually stored wet. As it comes from the centrifugal it contains from 25 per cent. to 30 per cent. of water, and it is stored in closed boxes until required.

The drying of guncotton is carried out in a building with a lead floor and zinc-lined walls. It is fitted with racks for the trays on which the explosive is to be placed. Great care is exercised to prevent grit of any kind from getting into the building. Heat is supplied by blowing in hot air, and the temperature is kept at about 40° C. Guncotton is not usually dried until it is required for incorporation with the other ingredients of the explosive to be made, as it is so much more safely stored wet.

Compressed Guncotton. A very large proportion of the guncotton manufactured is used in the form of compressed slabs. In making compressed cotton the drying described above is not carried out. Guncotton is uniformly mixed with pure water, when the exact weight required for the slab has been weighed out, by means of a stirring arrangement. This wet cotton is placed in moulds, in which the required slab is shaped, and a large part of the water pressed out. The pressure at this stage is usually applied by hand, and the slab, though of the correct shape and area, is still about three times the weight required, after it has been moulded. In order to reduce it to the right thickness and the desired solidity, hydraulic pressure is necessary. The pressure used is very similar to an ordinary hydraulic press, capable of exerting a pressure of from 7,000 lb. to 15,000 lb. to the square inch, but has certain slight modifications. The finished compressed slabs, if required for building up charges for mines, etc., must be of a smooth surface so that they will fit closely together. In order to get the surface smooth and even, the slabs have to be planed, filed or turned, as their shape makes convenient. The compressed cotton should contain at least 30 per cent. of water in order that this trimming may be done safely, and the surface coming in contact with the tool must be kept cool by a constant application of cold water. When

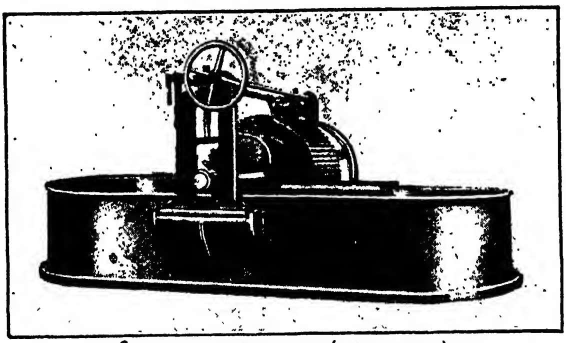
slabs are required with holes through them too small to be conveniently made under the press, they are drilled out in the ordinary way, heating being prevented by means of cold water

Collodion Cotton. The manufacture of collodion cotton, or soluble cotton, depends for its success greatly on the proportions and strength of the acid mixture. The process of nitrating and washing is the same as for guncotton. The proportion of the acids averages about 50 parts of nitric to 50 parts of sulphuric, and more water is present, but the time during which the cotton is allowed to remain in contact with the mixed acid is much shorter than in the case of guncotton.

There is no difference in appearance between cotton fibre and nitrated cotton fibre. Of course, after the fibre has been destroyed in the pulping machine the nitro-cotton loses its characteristic appearance, and on drying is a fine soft white dust. Wet guncotton is not considered an explosive, and the rules and regulations regarding explosives do not apply to it until it is dried. Thus the buildings in which it is stored while wet do not need to be isolated like nitro-glycerin buildings. The drying-rooms or stores, however, into which the cotton goes wet, to come out again dry, are considered as explosive buildings, and arranged accordingly.

Other Nitro-bodies. Many other substances have been experimented with, with a view to forming explosive nitro-derivatives, and a number of such compounds are actually in use. Picric acid, which is the tri-nitro derivative of phenol, or carbolic acid, is the most important of these. It is formed from phenol by first forming a compound of the latter with sulphuric acid and then precipitating the phenol-sulphuric acid by means of nitric acid. The picric acid thus formed must be washed free from sulphuric acid. Picric acid is a bright yellow crystalline solid which has a very bitter taste, and is slightly soluble in cold water, and more readily in hot water. It was long used as a dye before its explosive properties were discovered. Its principal application in the explosives industry is in the manufacture of the French explosive, melinite, and the British lyddite. In its original form, melinite consisted of 30 per cent. of guncotton and 70 per cent. of picric acid, but it is stated to be greatly altered. The composition of lyddite is not generally known, but it is stated to be picric acid melted, and run into moulds, together with an oxidising agent.

The nitro-derivatives of benzene and its homologues are also used in the preparation of explosives. They are not so highly explosive as nitro-glycerin or nitro-cotton, but in combination with oxidising agents they are frequently used. Thus roburite is a mixture of di-nitro-benzol with ammonium nitrate. Another such explosive is composed of nitro-toluol and potassium chlorate.



6. PULPING MACHINE (Fried. Krupp)

Detonators. A considerable industry connected with explosives is that of making percussion caps [see page 6618] and detonators. The detonators now used for exploding charges in mines, etc., may be said to be simply very large percussion caps. Mercuric fulminate is the substance always employed. It is prepared by acting on 1 part by weight of mercury with 10 parts by weight of nitric acid (Sp. gr. 1·4), the solution heated and 8·3 parts by weight of methylated spirit added. The fulminate settles in crystals, which are thoroughly washed. Still in its wet state the fulminate is taken to drying-rooms, where it is spread on the topmost of a series of layers of cloth, which cover a steam-heated copper table. The water is driven off at a low heat, and when cool the fulminate is taken to the mixing-room, where it is mixed with 25 per cent. of chlorate of potash.

The detonator factory, for its size, occupies a good deal of ground, the huts being placed widely apart, and surrounded with high brick walls or mounds of earth. The detonator tubes are made of drawn copper, and vary in length from 1½ in. up to 6 in. The average diameter is about the thickness of an ordinary lead-pencil. The tubes are filled into plates containing one hundred, and are charged with the mixed fulminate. The fulminate is subjected to pressure sufficient to reduce its bulk to one-half its loose state. The detonators are then cleaned and packed in boxes containing sawdust. Fulminate of mercury is an extremely sensitive substance, a scratch with a pin being sufficient at times to explode it. These detonators in use are ignited by means of safety fuses, or by means of electricity. Safety fuses are simply a train of gunpowder contained in a tube of fabric covered with a more or less water-resistant material such as pitch. Electric fuses are made on two systems, which have been named High and Low Tension. The former consists of a readily ignitable mixture covering the ends of the wires, which are fixed in the detonator tube in close proximity to the fulminate. The latter consists of a bridge of fine platinum wire connecting the ends of the two wires and surrounded by a fine dry guncotton. When a current of electricity is passed over the wire it sets fire to the combustible substance, which in turn ignites the fulminate, and this, being placed within or in close contact to the charge of explosive, detonates the latter.

There are six factories in Great Britain engaged in the manufacture of dynamite and blasting powders generally; twenty-two factories for making nitro-compound explosives (dynamite, guncotton, smokeless powders); fourteen factories for making fuses and fog-signals; and in the aggregate the number of factories authorised for the manufacture of all kinds of explosives was 150 in 1902.

ARMS AND AMMUNITION *concluded*

DYEING IN VARIOUS INDUSTRIES

The Dyes Used and the Processes in Dyeing Stone and Marble, Sand, Horn, Ivory, Bone, Mother-of-Pearl, Celluloid, Glue and Soap

By HERBERT ROBSON

Dyeing Marble and Stone. Marble and stone in general have no combining powers for colouring matters of any kind, whether mineral or organic. The mineral pigments are always inorganic compounds of great stability, a circumstance to which they owe their pre-eminence in the matter of fastness, but which renders them inapt to take part in further chemical action after their formation.

Mineral pigments, however, can be formed in the outer layers of the article to be dyed, but they are not much used for marble dyeing. This is to be regretted as, although they give a little more trouble than the coal-tar dyes, they produce excellent results and at the same time greatly increase the durability of the stone and its resistance to weather. The particles of colouring matter deposited in the manner to be presently described in the very substance of the stone materially assist the natural cement present in giving strength to the mass, and in resisting the penetration of water and other destructive agents.

The only way to colour a stone is to form the pigment in the stone by soaking the mass first in one solution, and then in another, which by reacting chemically with the first will produce the pigment desired. For instance, the successive use of potassium ferrocyanide and ferric-chloride produce a blue. The use of solutions is, however, attended with considerable practical difficulties. In close-grained stones, such as marble or hard limestone, penetration is difficult, and when the second solution is employed the first portions of pigment produced are near the surface of the stone and hinder the penetration of the second liquid. The secret is to employ liquids which produce pigments of great body so that even a thin deposit just below the surface will give a sufficient colour.

Mineral Dyes for Stone. In this way satisfactory yellows can be got with chromate of lead, greens with arsenite of copper, blues with ferrocyanide of iron, and reds with iodide of mercury. The solutions must be used diluted and as hot as possible so as to secure penetration. The work is difficult and requires a good deal of practice, as the strength of the solutions, the necessary temperature, and the time to be expended vary within wide limits even with two specimens of the same kind of stone.

Solutions of verdigris in alcohol give a good green to stone, but a better vehicle for the verdigris is melted wax. When this is employed the verdigris must be as finely ground as it is possible to get it. When this precaution has been taken very good penetration is secured, and the wax has the advantage of assisting in the subsequent polishing of the stone.

An excellent yellow can be dyed on stone with an ammoniacal solution of auramine. The penetration is fairly good and the colour is very fine. Weber's method of dyeing stone, and especially marble with iron, deserves mention. The marble is painted over with tincture of steel as sold by the druggists (an alcoholic solution of ferric chloride). It is then dried and put in a damp place. The iron salt decomposes and ferric oxide and basic salts are formed in the body of the stone and colour it yellow. Permanganate of potash is an excellent brown dye for stone and gives extremely good penetration.

An excellent mineral black can be obtained by soaking the stone in an alcoholic solution of corrosive sublimate. The solution is applied hot with a brush till no more is absorbed. The stone is then wiped and enclosed in a chamber in which it is exposed to the action of sulphuretted hydrogen. The gas penetrates in a way which no liquid can do and forms black sulphide of mercury in the pores of the stone. It only remains to mention that acid liquids must not be applied to marble or limestone as they react chemically with the stone.

Natural and Coal-tar Dyes on Stone. As regards natural dyes, logwood and red wood are used, and to a less extent cochineal, dragon's blood, and gamboge. These are used by repeatedly painting the stone with a hot solution in methylated spirit of the dry extract obtained from the dye-substance. The painting is repeated, drying the surface after each application until the desired depth of tint has been obtained. Aqueous solutions of the extracts can be used for cheap work but they give hardly any penetration. Subsequent heating of the dry stone increases the fastness of the colour, but may make the shade somewhat paler, in which case some more tincture must be applied with the brush. Gambier and annatto answer well for brown, used in alcoholic solution.

The coal-tar dyes are largely used for marble and stone dyeing. Any coal-tar colour can be employed which will dissolve either in spirit or in fat. The penetration is aided by heat. It is clear that colours produced in stone by these means depend largely for their durability on the protection of the stone itself. It is, however, possible in some cases to mordant a stone by the use of hot aqueous solutions of dye and mordant used in succession so as to form a lake in its pores, but the difficulties attending the process are very great and it is never resorted to in practice except on a very small scale. Among the coal-tar dyes most used by the stone dyer are Methyl Violet, Nigrosine, Auramine, picric acid, Alkali Blue, Bismarck Brown, Rhodamine, Eosine and Fast Green.

Difficulties of Dyeing Stone. One general difficulty met with by the stone dyer, whatever may be the nature of the stone he is treating or of the dye he is using, remains to be mentioned. It is impossible to get any but a very small piece of any stone, whether natural or artificial, which is of absolutely uniform texture throughout. This want of uniformity is very apt to cause a similar unlevelness in the dyeing. In fact, dyeing forms a very good test of the differences of texture in a stone. Nothing can be done to counteract these differences but to get the most thorough penetration of the parts of the stone just below the surface that can be obtained, by the prolonged action of hot liquids. In this way

the different absorptive powers of various parts of the stone are to a great extent discounted. Where, however, there is a regularity in the differences of texture in various parts of a stone a skilful dyer can take advantage of the fact to produce ornamental effects. For example, agates are soaked in solutions of aniline dyes, whereby beautiful bands of colour are produced and show up the striped structure of the agate to perfection when it is polished and cut.

Dyeing Sand. Apart from a rather old-fashioned ornamental use, coloured sand is employed by hydraulic engineers. It is not an easy thing to dye, as the colour must resist water and rubbing. Good effects, however, can be got with the azo colouring matters. For instance, 100 lb. of sand can be dyed by dissolving 1 lb. of beta-naphthol and 1¼ lb. of caustic soda in 3 gallons of water. The sand is stirred up slowly in this and then, according to the tint desired, the requisite quantity of azo colour is added.

Dyeing Horn. Horns are outgrowths of the skin of the head of cattle, goats, sheep, the rhinoceros, etc., and are formed round bony processes of the skull called *horn cores*. They are of the same substance as hair and finger-nails and the feathers and beaks of birds. The antlers of a deer are bony and are not composed of horn. The horn of commerce is chiefly obtained from oxen, cows, sheep, and goats. The horn substance, like wool, is composed of carbon, oxygen, nitrogen, hydrogen and sulphur. The presence of sulphur is important to the dyer. Horn often requires bleaching before dyeing, on account of its strong natural colour in many cases. There is much difficulty in bleaching horn without injuring the fibre and loosening the cohesion of the tissue. Peroxide of hydrogen seems to be the safest agent and gives good results in careful hands. Andes recommends whitening horn with chloride of lead. This process has, however, the drawback that the lead salt blackens in time in the air of towns owing to the formation of lead sulphide.

Horn is dyed principally with coal-tar dyes, but dyewoods are also used to some extent. Black, though it can be dyed with anilines, is more commonly got by the use of a warm solution of lead salt, which forms lead sulphide with the sulphur of the horn. An equally good result is obtained with mercury sulphide instead of lead sulphide. Nigrosine or aniline and bichromate gives, however, better results. Logwood on an iron mordant is also sometimes used for black dyeing, the black being tinted with fustic in the usual way. Aniline dyes are best used in alcoholic solution. Methyl Violet, Bismarck Brown, Aniline Yellow, indigo-carmine, and Malachite Green are all favourite dyes. Greens are dyed on horn by combining a blue with a yellow. Heat should always be avoided in horn dyeing as it tends to warp the material, and this is one of the reasons for using spirit solutions of anilines. They require no mordanting, while the water-soluble anilines require a mordanting with caustic potash or soda and the penetration of the mordant is not very satisfactory if it is used cold.

Dyeing Ivory. Ivory has no chemical affinity for colouring matters. The permanence of any artificially produced colour upon ivory depends, therefore, on the protection of the bony matter into which the colour has penetrated to some extent. The processes employed in dyeing ivory are very similar to those used for bone, but there are two points of difference between bone and ivory which have to be kept in view. In the first place, ivory has far less organic matter in its constitution than bone, and, in the second place, it is much denser and closer in texture than bone.

The first of these differences is in the favour of the ivory dyer. He has no fatty constituents to contend with, and these are perhaps the worst difficulties in the way of getting level shades, and are very troublesome to remove. The second, however, cuts the other way. Successful dyeing of ivory depends little on the colouring matter used. Once a dye or a lake has been formed in the superficial layers of the mass the ivory is coloured, and the colour is protected by the hard tissue of the bone. Penetration is, therefore, the main thing to be considered, and it will be evident that prolonged heating is usually required in dyeing such a closely-knit substance as ivory.

Nearly all the ivory of commerce is made from elephant tusks, the canine teeth of that great quadruped, and weighing sometimes as much as 2 cwt. each. Khartoum, on the Upper Nile, has an important ivory market, but signs are not wanting that the African elephant will soon be a rarity.

Seasoning Ivory for Dyeing. Ivory must be seasoned before dyeing. If this precaution is not taken, the colour will be very liable to change or to rub off. The cutting of ivory has also a great influence on the subsequent dyeing. Sawing has a marked tendency to colour the ivory yellow, probably by reason of the heat developed during the process, and also possibly on account of rust particles upon the saw. It is a good plan when sawing ivory with a circular saw to have the lowest third or so of the saw immersed in water, whereby heating of the saw is prevented. Six months is a fair average time to store ivory for seasoning.

As will be gathered from preceding remarks, ivory is perfectly catholic in its reception of colouring matters, whether dyes, pigments, or lakes. Nevertheless, the whole art of ivory dyeing consists in a proper handling of the various synthetic coal-tar dyes. A few mineral pigments are used for ornamental work, but the methods of applying them are troublesome, and they are employed only when brilliant colours have to show some amount of resistance to exposure to the elements. Provided that time is allowed for proper penetration of the liquids used, ivory can be dyed by any of the processes in vogue in textile dyeing. It can be dyed in one bath with a substantive dye, or in two baths with an adjective dye and a mordant, or by reagents, which will cause the precipitation of an insoluble pigment in the cells of the tissue. The absorption of dyes of any kind is frequently assisted by a previous treatment of the ivory with dilute nitric or hydrochloric acid. The acid dissolves out some of the mineral matter of the ivory, especially from the very hard superficial layers, and thereby is a great assistance to penetration. The action of the acid requires skilled supervision, however. The hardness of the original ivory can be restored after the ivory has been scoured, rinsed, and dried by heating it in dry common salt, but the loss of strength is irremediable, and must not be carried too far.

Bleaching Ivory. As regards bleaching, which is often a necessary preliminary to dyeing light shades on ivory, one of the best bleaching baths is one of bran, unslaked lime, and water. Bleaching powder answers well, but must be used for a long time in a weak bath, and on removal therefrom the ivory must be rinsed carefully at once, and then dried in hot sawdust. If the rinsing is not thorough, the ivory is very apt to

crack on drying. Peroxide of hydrogen and sodium peroxide are also excellent for bleaching ivory, as is solution of sulphurous acid. Gaseous sulphurous acid —that is, the fumes of burning sulphur—must on no account be used, as the sulphuric acid formed rots the ivory. Old yellow ivory can be restored to its original colour by exposure to the direct rays of the sun. This fact is well known to pianoforte players, who preserve the whiteness of the keys by leaving the lid open in the sunlight.

Dyes for Ivory. Black is dyed on ivory with logwood and bichromate in two baths, and also with Nigrosine. Red is dyed with cochineal or Brazil wood. Another method is to boil scarlet wool in water, adding carbonate of potash at intervals until the dye is extracted. A little alum is then added, the solution is filtered, and the ivory is soaked to shade in the filtrate. The dye-liquor must on no account be hot, but it is advisable to have it warm to save time. Picric acid or other soluble dye gives an excellent yellow, as does fustic on a tin mordant. Blues are dyed almost exclusively with anilines, which have practically ousted indigo-carmine from the ivory painter's palette. Methyl Violet of various shades is used for violet. Alkanet was used before the discovery of the coal-tar colours, but its colours are very loose to light. Greens are dyed with anilines, or by combining a yellow with a blue. The old method was to dye a blue with indigo-carmine, fix with tin salt, and then turn to green in a fustic bath. Browns are dyed with anilines—such as Bismarck Brown—and with cutch, but most of the ivory in this country is dyed with permanganate of potash, like wood. Most of the aniline browns can be shaded with red or other colours. Greys are got with baths which are the same as for black, but weaker.

There is yet one method of treating ivory which, although it is scarcely a dyeing process, is well worth mentioning. The ivory is soaked in a weak solution of nitrate of silver in the dark until it has acquired a dark-yellow colour. It is then taken out, rinsed, and exposed below the surface of water to the direct rays of the sun. In a few hours the ivory will have assumed a deep velvety black colour, and it is then removed and rubbed dry with a clean cloth. Chamois leather will give a bright silvery lustre to the objects treated by the above process. When adjective colours are made use of, and the dye and mordant baths cannot be combined, the dyebath must always come first, and the ivory should be rinsed before going into the mordanting bath. The great rules are never to hurry the process, and to aid the absorption by a moderate amount of heat. In the case of very hard and close ivory a preliminary boiling in water, the ivory going hot from the water into the dye or mordant bath, is of great assistance. Solutions of coal-tar dyes in alcohol generally penetrate better than aqueous solutions, but the latter are, of course, cheaper than the former.

Dyeing Vegetable Ivory. Vegetable ivory is the kernel or albumen of the seeds of a South American plant known as *Phytelephas macrocarpa.* The seeds are about the size of a hen's egg, and grow from four to nine together in clusters, which sometimes weigh 25 lb. or even 30 lb. It is always dyed with coal-tar colours, but the dyeing requires special experience, as the texture of the substance varies greatly with the age of the plant, the time of harvesting, and with the variations in the climate which occurred during the ripening of the fruit.

A few general rules, however, can be laid down. The ivory must be perfectly clean to begin with. It must be entered into plain water, and the dye gradually added when the bath has been brought to the boil. Great care must be taken to keep the bath constantly boiling during the dyeing, and to add the dye only as it is taken up by the ivory—that is, to keep the bath itself clear and light in colour. As soon as the proper shade is reached, the ivory is at once removed and dried without rinsing. It is then carefully polished with a clean and very soft woollen rag.

With the softer kinds of vegetable ivory a boiling with soap, followed by a good rinse, helps the absorption of the dye. Among the coal-tar colours used, Nigrosine, picric acid, Malachite Green, Methyl Violet, and Fuchsine are the most generally employed. Dyewoods are still used, however, to some extent, especially cutch and logwood. A good black, is got by boiling in a strong solution of logwood extract for half an hour or more, according to the closeness of the texture, and then mordanting in a cold bichromate bath. With cutch for brown, the mordant used depends on the shade. Ferrous sulphate, bichromate of potash, and sulphate of copper are all used.

Dyeing Bone. The dyeing of bone is a comparatively easy matter, as the coal-tar dyes penetrate it very readily, especially in hot solutions. In the great majority of cases no mordant is required, as the substantive dyes answer every requirement. In the case of the basic dyes, the best mordant is tin-salt. It is a good plan to facilitate the penetration of the substantive dyes, and also of any mordant that may be used as a preliminary to working with any adjective dye, by dissolving out part of the lime salts of the bone by means of dilute nitric or hydrochloric acid. This is, however, a very delicate operation, as, if it is carried too far, the appearance will be spoiled and it will become apt to crack or even to crumble. It is nevertheless an indispensable preliminary to treatment with aqueous solutions, although in most cases alcoholic liquids penetrate well without its aid.

Tannin must not be employed as a mordant. It acts upon the gelatin in the bone, and not only prevents proper penetration of the dye, but is absolutely destructive to all uniformity of shade.

Dyewoods, especially logwood for black, are used in bone dyeing, but, as in other departments of dyeing, they are rapidly giving place to the artificial colouring matters. Nigrosine dyes bone black without any mordant, and without heat, for example, and has therefore an advantage over logwood in every possible way. The best yellow dye for bones is picric acid, which can be toned by the simultaneous use of other yellows. The faster colour got by mordanting in a hot solution of bichromate and then dyeing in a hot solution of a lead salt is now rarely seen. Reds and blues are dyed with many substantive coal-tar dyes. Blue can also be dyed with indigo-carmine, but the bones must be first treated with dilute acid.

In all cases, the coal-tar dyes should be used in solution in spirit. It is an excellent plan to dye in a still, by which means a large proportion of the methylated spirit used is recovered, while the heat greatly favours the penetration of the dye. The use of water should be avoided in dyeing bones with artificial dyes on account of its softening and dissolving action upon the gelatin of the bone. In some cases, however, the gelatin has been to a large extent removed by bleaching the bones in boiling lyes or in a solution of chloride of lime or sulphurous acid. In this case the use of water in dyeing is not so objectionable.

The best results are always got by dyeing perfectly fresh bones. These, when thoroughly cleaned from adhering particles, want no bleaching as a rule even for dyeing light shades. When bleaching is indispensable, the best agent is peroxide of hydrogen, used after the exterior of the bone has been freed from grease by rubbing with petroleum ether. If sulphurous acid is used it should be employed in concentrated aqueous solution so as to act quickly. The gaseous acid is not suitable for bleaching bones as it has a tendency to warp the fibre.

Dyeing Mother-of-pearl. Mother-of-pearl is difficult to dye on account of its hardness and close texture. It is usual to dye the finished object, such as a button, as it is impossble to dye through thick material without injuring the lustre; articles made out of mother-of-pearl dyed before fashioning remain colourless at the edge. The rough and damaged places of the button or other article are first dyed; the dye goes most strongly into defective places, such as edges and cracks, so they become coloured before the lustrous surface is dyed. Mother-of-pearl is sensitive to the action of chemicals, and hence it is necessary to use very weak acid solutions, only lukewarm, and to let them act for the shortest possible time only.

Mother-of-pearl is yielded by a large number of mollusca, and various kinds of it are recognised in commerce, such as white, black, goldfish, burgos, etc. The various kinds differ in hardness, strength, lustre and colour, and in their receptivity of dyes and in the dyed effects they produce.

The following are the most important sorts:

Egyptian mother-of-pearl, from the Red Sea and the Persian Gulf. This has little lustre and is bent into small trough-like shapes.

Macasoar mother-of-pearl, from Australia. This consists of white flat shells with a high lustre. A single shell may weigh over 4 lb.

Manila mother-of-pearl, which is yellowish, and very lustrous and iridescent.

Lingah shells, trough-shaped, and having a bluish green shimmer.

Tahiti mother-of-pearl, the best black sort; the inferior sorts are called Gambia.

Auckland mother-of-pearl, flat, thin and greyish.

Banda Onithisif pearl, consisting of second rate bluish shells with yellowish green edges.

Mulles, consisting of whitey-blue shells with red edges.

Sea ears, especially Japanese, having a splendid lustre, are chiefly used for panels.

Burgos, which gives good effects on dyeing.

Mississippi. This variety consists of thick shells, white and very hard, and difficult to work.

Preparing Mother-of-pearl for Dyeing. The first thing to be done is to free the mother-of-pearl from grease, and, if light colours are to be dyed, it must then be bleached. The grease is removed by treatment with benzene, ether, or tetra-chloride or carbon, followed by ammonia, or a three to five per cent. solution of carbonate of potash or soda. Caustic soda corrodes some kinds of mother-of-pearl. The cleansed material is rinsed in water, and should be fingered as little as possible.

The dyeing is done cold, if possible, and it is better to dye for a long time in a warm bath than to hasten the process by greater heat. Many dyes—for instance, Chrysoidine—go on nearly instantaneously. Others, such as Tartrazine and Quinoline dye only slightly after long standing. The greater the lustre of the mother-of-pearl the harder it is to dye it. As the dye ought not to injure the lustre, time should only be allowed for the dye to get into fine cracks, and between the layers, watching the process with a good magnifying glass.

The organic matter generally takes the dye before the mineral portion of the shell, and in many cases forms lakes, which hide the iridescence too much.

Dyeing in Aqueous Solution. The old process with silver salts often combined with aniline dyeing with the idea that the colour is then faster. To imitate black mother-of-pearl, the most prized variety, immerse it in a solution of 4 oz. of nitrate of silver in 100 oz. of ammonia; tilt the vessel about from time to time, and after a few days' immersion in the dark expose it to diffused sunlight. The colour can be strengthened with pyrogallol. In dyeing "natural black" the object is exposed to sulphuretted hydrogen as well as daylight. Whatever may be done the black is really nothing more than a slate grey. It can be browned with dilute tincture of iodine.

A solution of indigo-carmine in twenty times its weight of boiling water is used for blues; and picric acid and indigo-carmine for greens; curcuma for yellows. A fine cheap brown is got with permanganate of potash.

Of the artificial dyes, the basic ones go on faster for the most part, and they combine also with the mineral matter. The acid dyes combine with the organic matter only, as can be seen on microscopic examination. No mordant is needed with the basic dyes, but a little acetic acid should be added to the water used to dissolve the dye. Before dyeing, the mother-of-pearl must be cleansed and well soaked with water. Dissolve from 1 to 3 per cent. of dye in water, warm if necessary, to from 50° to 60° C., and leave the pearl in the bath till it has the right shade. The following basic shades answer very well in a warm neutral bath: Chrysoidine, Bismarck Brown, Leather Brown, Leather Yellow, Phosphine, Auramine, Magenta, Victoria Blue, Methylene Blue, Methylene Grey G or NO, Navy Blue, Methyl Violet 2R, 6B, or R, Crystal Violet, Brilliant Green, Malachite Green, Safranine, and Rhodamine B, 5B, or G. Chrysoidine and Vesuvine dye very quickly. Victoria Blue, Rhodamine, Indoin Blue BB, Rubine, Brilliant Green, and Guinea Green dye quickly with 2 per cent. of alum.

Dyeing Mother-of-pearl with Acid Dyes. In dyeing with acid dyes, make the dye to a paste with acetic acid, adding to the bath a little oxalic acid. This addition should be always made with Fast Red A, Navy Blue, Ponceau R and 3R, Cotton Blue, and Azo Yellow. The following are the best acid dyes for mother-of-pearl; Acid Green, Guinea Green, Acid Magenta, Acid Violets N, 5B, and 6B, Water Blue, Lyons Blue, Naphthol Blue, Fast Blue, Ponceau 2R and 3R, Orange II., Mandarine Fast Yellow, Fast Blue, and Induline. All eosines and erythrosines do well. Nigrosine answers well, but Quinoline Yellow and Uranine do not.

Fine browns and blacks are got by combining Magenta and Malachite Green, Bordeaux by combining Magenta with Bismarck Brown. To get a fine black with a greenish shade, dye with Malachite or Acid Green, and cover with Nigrosine.

Fine beiges and Havanas are got by combining Chrysoidine or Bismarck Brown and Fast Blue or Nigrosine. Equal parts of Rhodamine B and Orange II. give a brilliant red.

In dyeing with adjective dyes, the result is usually dull. The best dyes are Alizarine Red, PS or W, Alizarine Blue W and Black W, Anthracene Brown W, and Alizarine Orange W. Dye at the boil with Turkey red oil and ammonia, or ammonia only. Dyeings with the zinc dust and alkali indigo

vat do not answer very well. Indigo-carmine gives better results. Fine shades can be got by the prolonged action of organic compounds which become coloured on exposure to air—for instance, paraphenolene diamine, amidophenol dioxynaphthaline and pyrogallol—mordanting first with cuprate of ammonia or with pyrolignate of iron. We can also use the substantive dyes, such as Congo, Benzopurpurine, Diamine Blue, or Bordeaux Oxamine Blue, and the Immedial dyes; but the results have no good lustre, and the mother-of-pearl is often attacked by the alkaline bath.

Dyeing Mother-of-pearl in Spirit Dyes. This method is the easiest, but the colours obtained are looser than the above. The first process is to soak the mother-of-pearl in a solution of carbonate of potash in ten to twelve times its weight of warm water. In this solution the mother-of-pearl is kept for an hour or so. This opens the pores and permits the absorption of the dye, and also gets rid of any grease that may be present. The mother-of-pearl is then rinsed and dried. No exact time for the action of the lye can be given, as it depends on the shade required. Up to a certain point, the longer the carbonate of potash is allowed to act the more dye the mother-of-pearl can absorb, and so the darker will be the shade. Reds are dyed with spirit solutions of any spirit-soluble red dye; yellows with tincture of picric acid or Aniline Yellow. Curcuma, gamboge, or Persian berries can also be used as tinctures. Blues are dyed with a spirit coal-tar blue, or with sulphindigotic acid diluted with water according to shade. Indigo-carmine is also employed. Greens are got either with a spirit-soluble green, or by combining a yellow and a blue; browns with a spirit solution of a coal-tar dye, or with tincture of iodine. Violets are dyed with spirit-soluble anilines, or with a solution in water of indigo-carmine turned to shade with liquid ammonia.

Dyeing Celluloid. Celluloid was accidentally discovered in the search for high explosives, and is a compound of guncotton and camphor. Its dangerous character has been enlarged upon, but it is entirely harmless if it is kept out of the way of sparks or flame, and it is very easily worked and dyed. It can be carved or turned like wood or ivory, and, moreover, unlike these materials, it can be moulded. When it is steeped in boiling water it becomes malleable, and can then be moulded into any desired shape, which it will retain on cooling. This ease of manipulation has caused it to find a large number of uses, and although many of these are to be condemned, it is very suitable for some purposes.

It is largely used for the handles of surgical and optical instruments, and in these articles it has to a great extent supplanted ebonite, on account of its far lower price. Washable collars, fronts, and cuffs are made by covering both sides of a piece of linen or calico with a thin coating of celluloid, securing a smooth surface and adhesion to the fabric at the same time by subjecting the material to heavy pressure between rollers.

As it is translucent and easily dyed, celluloid is largely used for cigarette and cigar holders and for mouthpieces of pipes. Quantities of "tortoise-shell" combs are made of it, and it masquerades as "ivory" for card-cases, visiting cards, photographic mounts, flower vases, cane and umbrella handles, piano keys, billiard balls, toy balloons, napkin rings, and many other small articles. It is dyed also for these uses and for making artificial flowers. It forms an excellent sheathing for ships' hulls, being far cheaper than copper, and far more durable. Curiously enough, however, although this fact has been known since 1881, prejudice and conservatism have successfully resisted hitherto the introduction of celluloid into the shipbuilding trade. This use of celluloid will undoubtedly become one day the most important of all. No marine organisms will grow upon it, so that its use would obviate all necessity for using poisonous and expensive anti-fouling compositions.

The only objection to celluloid is its inflammability, and when articles formed of it are worn, such as combs and collars, this has caused very serious accidents. All the numerous attempts so far to make celluloid uninflammable without affecting its usefulness have failed. So far they have taken two directions. On the one hand, chemists have tried to make a "non-flam" celluloid by adding a third substance, such as a silicate or borax. On the other hand, attempts have been made to substitute an uninflammable substance for the camphor. There is no doubt that a fortune awaits the inventor of an absolutely harmless celluloid.

Celluloid is invariably dyed with coal-tar colours. For single colours the coal-tar dye is added to the materials in the process of incorporation. For dyeing patterns on celluloid, the finished article is coated with a resist, usually paraffin or beeswax, and the parts to be dyed are then laid bare. The whole article is then immersed in a cold solution of the dye. In a few cases heat may be required to make the dye penetrate, in which case a comparatively infusible resist, such as asphalt, is used. In no case, however, may too much heat be used, or the celluloid itself will be softened and lose its shape.

Dyeing Glue and Gelatin. Dyeing these substances, which are virtually the same, glue being merely impure gelatin, is a simple matter enough. The uses of both glue and gelatin depend upon their complete solubility in hot water, and hence it is evident that only such dyes as possess equal solubility are suitable for dyeing them. At the same time any dye which has that property can be used, provided also that if the gelatin is to be used as food the dye is a non-poisonous one.

Dyeing Soap. The dyeing of soap appears to be merely an act of making a mechanical mixture of the dyestuff and the soap. There is no chemical combination between essential constituents of a soap and the colouring matter, such as occurs when vegetable fibres are dyed, and with animal fibres to a still greater extent. Nor is it desirable that such should happen with soap. The dyes which dye textile fabrics substantively—that is, without the intervention of any third substance or mordant—do so by forming with the fibre a substance or substances insoluble in the liquids which come into contact with the fabric under ordinary circumstances. It is evident that the formation of such bodies when soap was dyed would be quite out of place. A soap is not intended to be insoluble in water, and all of it that goes to form a lake is wasted, besides forming an unpleasant sediment in the water. For the same reason, the use of mordants is, of course, to be avoided in soap-dyeing, as their function is to form insoluble lakes with the dyes. It is true that in this case there is no loss of soap, but the objectionable sediment will still be there and will be very apt to stain the skin or articles washed with the soap.

DYEING *concluded*

THE RELIGION OF MAN

Beginnings and Primitive Elements of Religion. Religion is not Ecclesiasticism. The History of the Ecclesiastical System and the Doom of its Power

By Dr. C. W. SALEEBY

THE modern scientific study of mankind has enabled us in some cases to lay down propositions which have been definitely proved to be true of men everywhere as they at present exist upon the earth. For instance, we are able to say positively that some form of marriage, however degraded, exists amongst all human societies at present extant, and that there is no human society which does not punish infidelity on the part of the married woman. Similarly, we are able to state as a scientific fact that there is no known race, tribe or society of men—with the doubtful exception of the Veddahs—which is without a religion. Arguing, as in so many other instances, from the existing facts to that remote past of humanity which we cannot directly see, we may reasonably infer that the origin of religious beliefs is exceedingly remote, and that since they first arose man has been "a religious animal." Doubtless there may be found in high or in low societies isolated individuals who are completely non-religious, having neither beliefs nor interests that can come under this category. But these are relatively rare and abnormal exceptions. Anthropology clearly indicates that man in general is a creature who creates among other things religious beliefs.

The Beginning of Religion. It is possible, the present writer thinks, for psychology to indicate to us with absolute clearness the point in the evolution of man at which religion began to play a part in his history. It was, we believe, that point at which man first became self-conscious, being, as Hamlet says, "with such large discourse, looking before and after." The conscious but not self-conscious dog has no religion, no place for a religion, no possibility of a religion. It is the being who looks before and after who is religious. Now, if we be asked whether any point can be named, even in the light of modern evolutionary beliefs, at which the predecessor of man became man, the answer must surely be that it was the point at which he achieved self-consciousness: and then assuredly religion must have been born. If these assumptions be correct it is coæval with mankind, and if we assert, as we are entitled to do, that something which is of the nature of religion is an almost necessary attribute of a self-conscious creature, then we may be assured that, as religion has been coæval with man, so it will be coæval with him, even though its

"Outward forms that bear
The longest date do melt like frosty rime,
That in the morning whitened hill and plain
And is no more."

In our brief survey of the history of religion we are compelled to recognise that, in its origin, its relation to anything that we can now call truth is at the very best almost desperately remote.

Primitive Religion. Primitive religion, in a word, is pure superstition, grossly false, without any relation to morality; and when it first assumes a relation to morality it countenances and insists upon such practices as human sacrifice, which are essentially immoral. We need not hesitate to admit what in any case we must admit, provided that we fully appreciate the monstrous falsity of the argument which would seek to discredit all religion on account of the facts of its whole history. The same argument would, of course, discredit all science. Primitive science was simply superstition; indeed, primitive religion and primitive science were one and the same, and both were equally false. If all religion is to be discredited because it began in beliefs we cannot now share, so must we discredit all science—which began with those same beliefs.

The Roman writer, Petronius Arbiter, laid down the doctrine that "Fear first made the gods." On his part we may say that this was a guess, or rather that he inferred it from his observation of human nature, without having made any comparative anthropological study. Precisely the same is the case of our own writer Hobbes, who said, "The Feare of Things invisible is the natural Seed of Religion." The comparative study of the beliefs of man is of much later date than even Hobbes, but it has abundantly and conclusively demonstrated, by the inductive method, the truth of the proposition which he and his Roman predecessor expressed. This is to say that earnest students all over the world have found fear of the invisible, and of the visible too, to lie at the basis of the lowest religions now extant: and no one questions the propriety of the inference from the lowest forms of existing religion to its earliest stages—now gone for ever.

The First Forms of Religion. There has been definitely abandoned, as without any warrant at all in facts, the theory that the lowest forms of religion described by missionaries, men of science and others, are cases of degeneration from a primeval monotheism or belief in one God. At one time this opinion was generally held, and it was supposed that only under special guidance was man able to preserve in its purity the belief with which he started. This opinion, however, was essentially pre-evolutionary, and we now know it to be untrue. It is now maintained by no one.

Let us now ask ourselves whether it is possible to express in any kind of category the forms which primitive religion took, and which it

still takes in primitive peoples or in minds of the primitive type. There has been wide discussion, that still persists, as to which form of primitive religion was really the first. It is impossible to discuss this matter here, but the controversy rages between those who insist that ancestor-worship is the primitive religion and those who insist that Nature-worship is the primitive religion.

The Worship of the Dead. Ancestor-worship is, at any rate, an indisputable form of religion. According to Herbert Spencer, who based his theory upon very wide study of the psychology of the savage, religion took its first form in ancestor-worship, which itself arose in dreams. As John Fiske says ("The Idea of God," page 66): "No one has ever discovered a race of men devoid of a belief in ghosts. This belief may clearly be traced to the facts of dreams. The savage, unlike the educated man of to-day, makes no sharp distinction between the reality and validity of his waking experiences on the one hand, and the experiences of sleep—namely, dreams—on the other hand. The contemplation of the facts of sleep, which to the observer suggest the absence of the informing inhabitant of the body, and of the facts of dreams, which seem to prove that the inhabitant, while out of the body, may roam afar and then return—these gave rise to what is, perhaps, the first speculative belief of the human mind—the belief in ghosts."

If now we consider the case of death, we shall see how the same theory is applicable to it; nor is it difficult to understand how the ghost of, for instance, a great chief may be regarded as still powerful and demanding obedience and respect. As to the absolute priority of this kind of belief as against a belief in the presence of informing spirits in the sun, the trees and other phenomena of Nature, we may merely quote, without commenting upon it, the argument of Herbert Spencer that surely a belief in the spirits of the dead—who have lived—must have preceded a belief in spirits of such an object as a rock; this second belief would spring from the first.

The Fear of the Dead. However that may be, we find this element of the worship of the dead in primitive religion, probably as the primitive religion; and it is our duty before we go any further to rid ourselves of a very common misconception as to its character. We commonly think of this form of religion as ancestor-worship, and this word suggests to us the name of such a great moral teacher as Confucius and the practice of ancestor-worship as it may now be seen in China and Japan. But we are profoundly in error if we imagine that modern ancestor-worship, moralised and beautified by the slow progress of the human mind, is one and the same thing as primitive ancestor-worship. That there are beautiful elements in the modern practice we all admit. We read of simple and noble Japanese ceremonies, which, though we may believe them to be based upon erroneous beliefs, yet undoubtedly have fine elements in them. But the primitive worship of those who had been powerful in their lives was a thing awful and horrible to contemplate. It had no vestige of a moral element. It was rooted in fear, and fear alone kept it alive; it was not originally the worship by a given man of his own especial ancestors; it was simply the fear of those who had been dangerous and tyrannous in their lives, and who in their now invisible shape were more terrible than ever. In order to placate the feared departed, the living were burdened, were tortured in body and in mind, and unthinkable thousands of men, women, and children were slain. There has been no more horrible thing upon the earth than the beginnings of religion. Primitive religion contains no moral elements, but, on the contrary, constantly defies and denies the laws of love and the sanctity of life. It contains no elements of value to the intellect of man or to his sense of beauty. That anything good and great should arise from such ghastly beginnings is one of the great marvels, as it is, perhaps, one of the great lessons and parables, of human history.

Nature-worship. The other form of primitive religion is Nature-worship. Here we do not ask whether it was later than ancestor-worship, or earlier, or of independent origin. Of its essential superiority to the primitive worship of the spirits of the dead—which, be it remembered, was only a worship of the spirits of the dangerous dead—there can be no question. However gross its superstition, it had in it elements which made for higher things, just as primitive ancestor-worship, as we have seen, was capable of developing into such things as reverence for aged parents. Primitive nature-worship began as a belief in the incarnation, so to speak, of active and more or less potent intelligences in the great material phenomena of the world around us. Its particular form depends, of course, upon the particular aspects of nature in various places. The mountain or the forest or the sea or the cliff may acquire special importance according to local circumstances. Certain great phenomena of nature, however, are common to all men, and chief among these are the heavenly bodies. The evident potency and majesty of the sun made him a more or less universal object of Nature-worship in innumerable forms. These take, of course, various more or less poetic shapes—poetic imagination being a very ancient attribute of man; and, according to the measure of the individual intelligence, the sun may be conceived as himself a living god or as a fiery chariot which daily carries the sun-god across the sky, or, more philosophically, as the symbol or sign of a god that is somewhere behind him.

The Forms of Science. Or the former belief may become still more subtle, as where, for instance, fire is conceived as the origin and regenerator of all things, and the sun is worshipped as the greatest visible manifestation of this creative power. From the remotest ages the sun has been an object of the worship of mankind, and it need hardly be said that the study of that single branch of comparative religion, which may be called *solar myths*, is a matter for endless volumes.

In primitive religions we find varying proportions of both of these primitive elements—

ancestor-worship and Nature-worship. That both arose in fear, there can be no question ; that it is difficult to observe in the beginnings of either much or anything that commands our respect can also not be questioned. Yet, as we have seen that the worship of the dead is capable of vast elevation, so also we must recognise, even in the rudest forms of Nature-worship, the germs of philosophy and science.

This last point must be insisted upon. It is perfectly evident that the fear of the great phenomena of Nature necessarily involves an interest in them, and that this interest necessarily involves their study ; but this study, whilst, among other things, it will assuredly diminish the original fear, so also gradually reveals many aspects of Nature hitherto unsuspected. The fear of eclipses, for instance, leads to an interest in eclipses, and this to their study, until it is found that certain eclipses recur at regular intervals. The fear has now vanished, and may well be replaced by a fine and all but religious wonder ; while there is slowly born the idea of natural law. In a thousand cases this process has occurred, until at last there is fully realised the idea, gradually becoming familiar to our own age, of the supreme unity and orderliness of Nature—and, therefore, of That of which Nature is only the manifestation. Thus it is not impossible to trace from rude beginninge, even from the agonies of fear in the savage heart at nothing worse or more significant than a shadow, the gradual development of one of the sublimest ideas which have yet found their way into the human mind.

The Birth of Knowledge. Observe how this fear, and interest born of fear, and study born of interest, and knowledge born of study, affects the idea of God. When Nature was conceived as an awful collection of more or less independent powers, who might war among themselves, but all of whom dominated over man, then evidently was the age of polytheism. Only with the growth of knowledge was it possible for this to be replaced by the immeasurably higher idea of monotheism. This step in the development of religion has unquestionably been due to the growth of knowledge. Contrary to the ordinary belief, science—which is the pursuit of truth—so far from being the enemy of true religion, is necessarily its best friend. Doubtless it has destroyed innumerable false religions, and that great work is not yet done ; doubtless the official exponents of those religions have had to suffer, and have sometimes honestly and sometimes dishonestly condemned the growth of knowledge as impious, and declared that there were things which we were not meant to know—as, for instance, when it was an immoral and legally condemned act to make any anatomical inquiry into the structure of the human body. But, on the other hand, it may assuredly be demonstrated that the growth of any order of truth, while it involves the destruction of falsehood, can never injure any other order of truth, but must, on the contrary, purify and help it.

Hitherto, we have considered briefly the main aspects of the genesis and development of religion in general in terms of its beliefs. There are, however, two other great facts of religion as history reveals it; one is the relation of religion to morality, and the other is the fact of religious institutions, which, in the widest sense of the word, may be called *Established Churches.* And first, as to the relation of religion to morality. It is one of the commonest and most erroneous of all popular beliefs that there is an essential relation between all religion and all morality. This belief does not withstand a moment's reflection or the observation of a single day. On the contrary, it is definitely known that whilst the greater part of past religion has been closely associated with the most horribly immoral practices, religion at its birth had no relation whatever, essential or accidental, to morality.

Morality is Older than Religion. Furthermore, it is an indisputable truth that morality, just as it precedes any kind of religious idea in a tiny growing child, so is also immeasurably older than any religion, even if we grant, as we must, that religion is probably as old, or very nearly as old, as man himself. The tigress that will give her life for her cubs ; the baboon whose case is mentioned by Darwin, and who, having gained a place of safety, returned, through his enemies, to rescue a little one that had been left behind—these are instances which demonstrate, what no one in the twentieth century can dispute, that the beginnings of morality can be traced far down in the scale of animal life. The lowest of known vertebrates is the fish, and among certain fishes there is found not merely maternal care—one of the oldest, the noblest, and most purely moral things in the whole world—but even a very much later thing, paternal care. Morality and religion have wholly independent origins, love being older and stronger than any church or any system of religious beliefs or practices that has yet expired, or has yet to expire, upon the earth ; while we observe also that the association of morality and religion in more recent times furnishes promise of the most precious kind for both. Among all living students of religion, not in its historical and comparative aspects, but in its aspects as a great fact in human life to-day, there stands out a sincere and noble and profound thinker, Professor Harald Höffding, of Copenhagen. In his "Philosophy of Religion" he insists that past students have paid too much attention to the transition in the history of religion between polytheism and monotheism, and that, as was originally asserted by Tiele, " the transition from Nature religions to ethical religions is the most important transition in the history of religion."

The Gap Between Morality and Religion. This is not to assert that before such a great transition occurred there was no moral element in religion. As Höffding says : " Since the worship of the family, of the clan, or of the nation is shared in by all, it helps to nourish a feeling of solidarity which may acquire ethical significance." In such a case, the fact of having common fears, if no more, may increase a man's sympathy with his neighbour, which is the

beginning, the end, and the whole of morality; but how tremendous is the gap between this stage, which may involve implacable hatred of those who have a different religion, and the command of Confucius, that we should do as we would be done by, or the final statement of morality in the words of Him who said, "But I say unto you, love your enemies, bless them that curse you, do good to them that hate you, and pray for them which despitefully use you and persecute you." (St. Matt. v. 44.)

Ecclesiasticism. There remains the necessity for alluding to a great world fact, which in modern terms is sometimes called *Ecclesiasticism* and sometimes *Clericalism.* With the birth of religion, or closely following upon it, there came the appointment or self-appointment of special individuals who had a special association with it. This fact makes the primitive "medicine-man" one of the most interesting figures in history, as the evolutionary germ of churches on the one hand and of science on the other. In him the differentiation had not yet occurred. Such scientific knowledge as he had or pretended to have was one with such religious knowledge as he had or pretended to have. He would transmit his pretended secrets, together with some small measure of real Nature-knowledge, to his children or to initiates. Thus, there arises a priestly race or caste or class. In its remoter past the existence of this class, together with the institutions which it creates, and with its close associations with any other governing powers that there may be—the union of Church and State being one of the primitive facts of society, preceded only by a still more primitive stage in which they were identical—was by no means a wholly undesirable fact.

Ecclesiasticism is not Religion. All students of primitive religion are compelled to agree as to the disciplinary importance of early religious institutions. The same is, of course, true of early military institutions. The record of war and of Ecclesiasticism is not a wholly pernicious one. They had their place and their function, constantly and closely linked, so that there was always the Ecclesiastical sanction for war which, when successful, of course increased the power and reign of the Ecclesiastical system. They made for the preservation and success of larger and larger societies, which at last could spare some of their own energies for their internal concerns, and thus made the first steps in the direction of civilisation. Such propositions as these are quite distinct from any assertions as to the relations of Ecclesiasticism to essential morality. There is no essential morality in discipline, for instance, any more than there is essential morality in obedience—which, in the history of man, has far oftener been vicious than virtuous. But such things as discipline and obedience, strongly aided by the Church with its secular arm, have played an apparently necessary part in the past development of large societies.

That there is no essential relation between Ecclesiasticism and religion is evident directly we grasp the idea that religion is either a personal matter or not really religion at all; it is demonstrated by the fact that there have been and are unquestionably religious people who own no Ecclesiastical form or system; and far more by the fact that the supreme religious figures of history have been supreme because they have raised their brave and solitary voices against the established Ecclesiasticism of their day. By such Ecclesiasticism they have commonly been murdered.

The Greatest Murderer in History. The actual record of the so-called religion which establishes itself as a human institution is one of the few unmitigated horrors of the past. Ecclesiasticism has initiated and carried on countless unnecessary wars; it has made numberless martyrs; it is the greatest murderer in history; its murders have taken many forms, whether those of human sacrifices to a fetish in the heart of Africa or the burning of witches in our country only a century or two ago, or the burning of such great philosophers as Giordano Bruno, or the poisoning of Socrates, or the throwing of Christians to the lions by Roman Ecclesiasticism, or the murder of tens of thousands of Christians by Christian Ecclesiasticism, Catholics by Protestants, Protestants by Catholics, Christian missionaries by African head-hunters, or brave and faithful savages by a militant Christianity. Religious persecution has been initiated by all forms of Ecclesiasticism in all ages in precise proportion to their power.

Churches have at times displayed an interest in the advance of knowledge within due limits. Sincere and honest thinkers have freed their souls, even while their bodies still wore the garments of one Ecclesiasticism or another. Their reward has been the reward of Bruno. Ecclesiasticism, however, has never desired to share its knowledge with the people. In its own interests it has always desired to teach the people certain things—namely, such things as make for its own interests. To the growth of knowledge outside its own limits, and independently of its sanction, Ecclesiasticism, whether as Fetichism, or when taking to itself the noblest Name named of men, has necessarily been, and must continue to be until the hour of its death, an implacable foe.

The Dying Empire of Ecclesiasticism. There is no historian of human knowledge but lends his testimony, willingly or unwillingly, to this most shocking truth. Ecclesiasticism, however, is dying, and that rapidly. All over the world its empire can be seen to crack from day to day. If its almost measureless past be gazed upon, and its past potency, we may recognise that it is as good as dead. The immediate problem which faces mankind, and especially those who love the great religious truths, is as to how this noisome corpse is most decently and expeditiously to be buried. Thereafter these words of John Ruskin may be men's guide: "For there is a true Church wherever one hand meets another helpfully, and that is the only holy or Mother Church which ever was, or ever shall be."

Continued

BOOKBINDING & PUBLISHING

The Characteristics of Good and Cheap Bindings. Sewing with Cords and Tapes. Covering and Tooling. The Attractive Trade of Book-publishing

BOOKBINDING

By F. Sangorski and G. Sutcliffe

BEFORE entering upon the technical details of bookbinding, it will be advisable to give an explanation of the composition of a book, and of the sizes in which books are made. A book is printed on sheets, and the size of these sheets and the number of times which they are folded decide the size of the volume. The sheets are generally used in the following sizes: Foolscap, 17 in. by 13½ in.; medium, 24 in. by 19 in.; crown, 20 in. by 15 in.; royal, 25 in. by 20 in.; post, 19¼ in. by 15¼ in.; super-royal, 27 in. by 21 in.; demy, 22½ in. by 17½ in.; imperial, 30 in. by 22 in.

When the sheets are folded once they make a folio-sized volume; twice, quarto (4to); three times, octavo (8vo); four times, 16mo; and five times, 32mo.

A book is said to be a "crown 8vo," or a "demy 8vo," when sheets of "crown" or "demy" size are folded three times. When folded, each sheet is called a *section*, and consists of the number of "leaves" into which the sheet has been folded—an 8vo volume having, for instance, eight leaves in each section—each leaf consisting of two pages. The top edge of a book is termed the *head*, the bottom edge the *tail*, and the front edge the *fore-edge*.

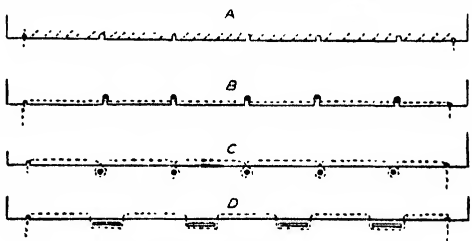
Bookbinding is divided into three branches—sewing, forwarding, and finishing. With sewing are included all the processes which ultimately end in the sewing of the sections together. Forwarding comprises the processes which complete the binding of the book; and finishing, the processes which result in the decoration of the binding.

Machine Binding. The demand for inexpensive binding, brought about by the increase in cheap literature, has led to the introduction of machinery into the craft. With publishers' cloth bindings, the processes from beginning to end are carried out by machinery. But though by this means cheap work is produced, it is usually at the expense of the quality of the binding. If the best work be required, it must be done entirely by hand, with just the aid of such appliances as have been in use almost since the invention of bookbinding. As, however, there are now so many books that are not worth the expenditure necessary for the best binding, the use of machinery is compulsory; but a method should be adopted that will allow the use of machinery without seriously damaging the binding. The essential requirements of a soundly constructed binding are: (1) All sections broken at the back should be mended, and all loose leaves and plates secured to the sections with a guard; (2) the book should be sewn on at least five cords or four tapes, which should project from the backs of the sections; (3) the boards should be firmly attached to the book, all the cords and tapes being interlaced into the board; (4) the leather should be directly attached to the back; and (5) all materials used should be of sound quality, uninjured during manufacture.

With the exception of the cheapest work—cloth binding—there is no reason why all these requirements should not be met; but owing to the demand for a showy exterior at a low price they are not usually considered by the modern binder.

Modern Cheap Binding. Usually, if the sections are broken at the back, the practice is to cut off a piece of the back, thus making the section into single leaves, and to sew these leaves together in the manner shown in **1** A. This is called overcasting, but a section so sewn together will always be liable to break away from the rest of the book and will never open freely.

With sewing, the cords, instead of projecting from the back of the book, are sunk into the sections, saw cuts being made in the back, the level back thus obtained enabling the book to be backed by machinery. But the sewing is not nearly



1. SEWING BOOK SECTIONS

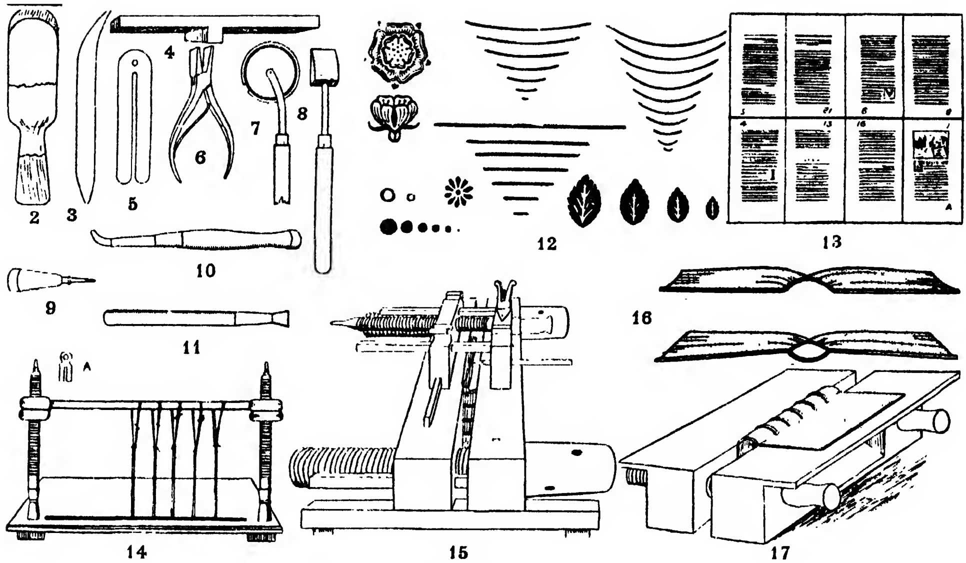
as secure, for instead of the thread passing round the cords as seen in **1** C, it merely passes across them as in **1** B; and if broken, the probability is that the section will come out.

All books that are to be backed by machine should be sewn on tapes. The sewing is secure [**1** D], and the tape does not make sufficient projection to prevent the machine being used.

Too thin a cord is generally used, and often two are cut off, and only the remainder interlaced into the board.

The sinking of the cords prevents the book opening well, and to get over this to some extent, the leather is not attached to the back. A hollow casing made of brown paper is glued on, and the leather attached to this. The leather is attached to the boards, and the boards to the book merely by the cords laced into them; consequently, all the strain of opening and shutting the book is placed on these cords, and they often break away, the book then coming away from its cover. If the leather is stuck directly on the back, it assists the cords in attaching the cover to the book [**16**]. The cords have been sunk into the book, but as the public have been accustomed to see the projections on the back made by the cords, false ones are stuck on.

Good Inexpensive Binding. For the best binding the book should be sewn on cords, and meet all the requirements we have mentioned. If the question of expense has to be considered, the decoration should first be discarded. After that, leather being needed principally on the back and corners, only these portions need be covered with leather, and the remainder with a



TOOLS AND APPLIANCES USED IN BOOKBINDING
2. Paring knife 3. Folder 4. Knocking-down iron 5. Trindle 6. Band-nipper 7. Fillet 8. Polishing iron 9. Bodkin 10. Agate burnisher 11. Bloodstone burnisher 12. Ornaments 13. Sheets for folding 14. Standing press A. Sewing-key 15. Press, with plough and pin 16. Correct and ordinary binding 17. Finishing press

less expensive material. This is what is called "half binding." For a further reduction the book should be sewn on tapes, and by this means an inexpensive and durable binding can be obtained.

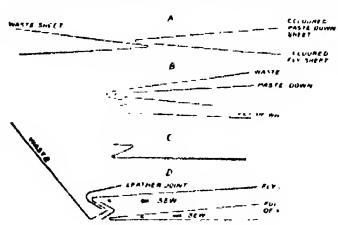
Following is a list of tools and appliances necessary: Standing press; sewing press [**14**]; sewing keys [**14** A]; bloodstone burnisher [**11**]; agate burnisher [**10**]; square; band stick; tenon saw; trindles [**5**]; bodkin [**9**]; pressing boards; cutting boards; backing boards; nickel pressing plates; set of letters, dots, rings, punches, leaves, flowers, gouges, straight lines, and other ornaments [**12**]; press with plough and pin [**15**]; paring stone; paring knife [**2**]; hammer; folders [**3**]; glue pot; compasses; band nippers [**6**]; knocking-down iron [**4**]; gold cushion and knife; pressing tins; millboard shears; finishing press [**17**]; finishing stove; fillet [**7**]; polishing iron [**8**].

If the book is received in sheets, these sheets have to be folded. We will suppose they are to be folded three times, making an 8vo volume. The sheets are lettered alphabetically in one of the corners [**13**]; these are called *signatures*. Usually, J, V, and W are omitted. The sheets are placed in alphabetical order with the signatures in the right-hand bottom corner. The first sheet is turned over, so that the signature comes face downwards on the left-hand bottom corner, and is folded in half from right to left, care being taken that the printing corresponds. A folder [**3**] is used to crease the fold. Pages 2 and 3 will now face. The top right-hand corner is then folded, and pages 12 and 13 will face. Folding in half, so that 8 and 9 face, completes the folding of the first section. The remainder are folded in a similar manner

Washing Stained Sheets. Any stained sheets are washed in the following manner: An ounce of permanganate of potash is dissolved in a quart of slightly warmed water. The stained sheets are put into this solution for about an hour, causing them to turn a dark brown colour; they are then taken out and washed in clean water. One ounce of sulphurous acid is put into a pint of water, and the sheets washed in this until all the stains have disappeared. They are again washed in clean water, and hung up on lines to dry. When dry, they are sized by dipping them into a solution of one ounce of isinglass dissolved in a quart of water, applying heat and again hanging up to dry. If the sheets are too white when taken out of the acid, the size is slightly tinted with tea, coffee, or any other staining fluid.

Making Endpapers. When all the sections have been made sound and the plates guarded on, endpapers are made. They are attached in the following way. Two folded sheets of white paper, similar in tone to that on which the book is printed, and a folded sheet of coloured paper, are required. The coloured sheet is pasted on to one of the white sheets as shown in **18** A. When dry, the white leaf marked "waste sheet" is folded over one coloured leaf, and the other white leaf folded back over the remaining coloured one, as in **18** B. The other folded sheet of white is then inserted where marked, and the end paper is sewn on to the book through this. The waste sheet is for the purpose of protecting the end papers during the binding, and is torn out when the endpapers are finally pasted down.

If a leather joint is used, the endpapers would be made up in the following manner. A white sheet is folded as in **18** C, and the coloured fly-leaf, leather joint, and waste sheet, are pasted on to this as in **18** D. A folded sheet of white is inserted, thus completing the endpaper, which is sewn on in the two places marked in **18** D. The endpapers are placed in their positions



18. ENDPAPERS

at either end of the book and then tins covered with paper are placed between every three or four sections and the book placed in the standing press for about twelve hours.

The positions of the cords or tapes on which the book is to be sewn are then *marked up* on the back. The book is knocked up square at the head and held in the lying press between a pair of pressing boards and the back is divided into six divisions. Five of these are made equal and the tail one slightly longer. On the five points thick pencil lines are drawn across the back. If tapes are used for sewing four are usually sufficient and two lines are marked for each tape. A slight saw cut is then made at the head and tail about half an inch away from the edge, and the book is ready for sewing.

Sewing the Sections Together. The book is sewn on five cords; the number sometimes varies with the size of the book, but five is the most usual; the thickness of the cords also varies according to the size of the volume. Five loops are made of ordinary string over the crossbar of the press; these are called *lay cords*, and are used repeatedly. To these loops are attached the cords on which the book is to be sewn, which are then passed down through the slit in the bed of the frame and fastened by means of keys [**14**].

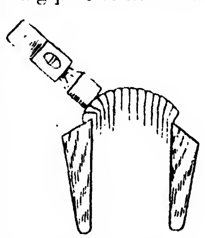
The book is laid down on the bed of the press with the back against the cords, which are moved into position so that they correspond with the lines marked on the back of the book. The cords are then tightened by screwing up the crossbar.

The endpaper is first sewn, the needle with thread or silk being passed into the section at the head and round each cord in turn and brought out at the tail [**1 C**]. The first sheet is then sewn from tail to head in the same way, and the silk is tied to the loose end hanging from the endpaper. Another section is sewn on and the needle is inserted between the previous sections and catches up the silk that joins them: this is called a *kettle stitch*. The remaining sections and endpaper are sewn on in the same way, the silk being fastened off at the last kettle stitch with a double knot. The cords are loosened, by lowering the crossbar, and are cut off about 3 in. from the book; the loose ends are then frayed out with a bodkin.

If the book is to be sewn on tapes, the tapes are set up on the sewing frame as with cords. The sewing is done as described above, with the exception that, owing to the width of the tape, the thread passes out and back into the section again at different points instead of passing out and in at the same point as with cord sewing [**1 D**].

Gluing Up, Rounding and Backing. The book is placed in the press with a piece of millboard on each side, and the back is glued. When the glue has set the book is laid down on its side and half of the back is rounded over with a hammer, it is then turned over and the other half rounded.

Backing is sharply emphasising part of the swelling caused by the thread used in sewing, by compressing the book near the back and beating the back of the sections, one over the other, making a sharp ridge against which the cover will lie. Placed between a pair of backing boards with the back projecting slightly above the boards, the book is lowered into the lying press. With a hammer the



19. BACKING

sections are then beaten one over the other, starting from the centre and going over equally on either side. The two outside sections are well beaten over the backing boards, for this makes a sharp groove for the boards to fit [**19**].

Preparing and Attaching the Boards. The best material for the boards is millboard owing to its toughness and thin substance. Two pieces are cut with the millboard shears about a quarter of an inch larger all round than the book. The edges that are to go to the back of the book are then cut smooth in the lying press with the plough. The boards are screwed up in the press with the amount that has to be cut off projecting above the bed of the press. The knife in the plough travels backwards and forwards level with the bed of the press, and whatever projects is cut off.

The boards are then each lined on one side with a piece of white paper pasted on. Two other pieces of paper, double the size, are pasted and the boards covered with these on both sides. The extra lining of paper on one side will cause the board to warp that way, and this side will be placed against the book to counteract the pull of the leather which will ultimately be pasted on the other side of the cover.

The boards when dry are cut to the size required, with the press and plough, and are then attached to the book. One board is laid in position on the book and a line is drawn on the board from tail to head about half an inch from the back. Lines are then drawn from the cords to this line. On these cross lines small V-shaped pieces are cut out of the boards to allow the cords to sink in level when laced, and holes are punched with a bodkin at the points where the lines meet. The boards are then turned over and holes are punched about half an inch from the previous ones. To attach the boards the slips are pasted and passed through the holes first made and then back through the other holes. They are then drawn tight, tapped with the hammer to fix them, and the ends cut off level with the boards.

If the book is sewn on tapes the selvedge of the tape is cut off and the tape can then be frayed out and interlaced, like a cord. When both boards are attached the book is put in the lying press, with the back projecting slightly; it is then pasted to moisten the glue on the surface, which is scraped off with a folder. The cords are nipped up and straightened with the band-nippers, tins are put on both sides of the boards, well up to the groove, and the book is left in the standing press, tightly screwed up, for about twelve hours. The knocking-down iron is then screwed up in the press, and the slips hammered down until they are impressed level with the board.

To cut the top edge the book is screwed up in the lying press with the back to the worker, the front board being lowered just the distance required for the "square," and the edge is cut with the plough [**15**]. The tail is next cut in the same manner.

For cutting the fore-edge the edge has first to be made flat by inserting trindles [**5**] between the book and the boards across the back. A cutting board is placed on each side and held in place while the trindles are removed. The book is then lowered, with the boards hanging down, into the press and the edge cut with the plough.

Gilding Edges. The back is knocked flat, and a cutting board placed on either side of the leaves, level with the fore-edge, and the book is placed in the press. The edge is scraped and finely sandpapered. A paste, made of powdered red chalk and water, is applied to the edge with a sponge and polished with a hard brush. The edge is then painted with a preparation of the white of an egg,

beaten up and diluted with water, called *glaire*. The gold leaf is cut into strips the width of the edge and applied to the edge with a soft flat brush. The book is left to dry and the edge finally burnished with a flat bloodstone burnisher. The other edges are gilt in a similar manner. The edges can also be stained. Water stains answer the purpose, and are applied to the edge with a soft brush, the edges being afterwards burnished with an agate burnisher.

Headbanding. Headbanding is the stitching on the head and tail of a strip of vellum, gut, or cord, to make a similar projection from the back as is made by the boards projecting beyond the edges of the book. As a book is usually pulled out of the bookshelf by the headband, it is important that this should be firmly attached to the book, and one that is made on the book is far preferable to one bought ready-made and stuck on.

The boards are lowered level with the edge of the book held in the lying press or plough, and a needle, threaded with silk, is passed into the edge and out at the back below the kettle stitch. Half the silk is drawn through, and then the needle is again inserted and drawn out. The silk now has made a loop into which a strip of vellum, slightly narrower than the "squares," and a little longer than the width of the book, is placed. The silk is drawn tight and a pin inserted in the edge at the left-hand side, behind the vellum, to keep it in position. The needle end of the silk is brought over the vellum and the other end crosses it and goes behind. This end is then brought over and is crossed by the needle end. The headbanding is continued in the same manner, being fastened down to the book about every quarter-inch. To do this when the needle end is at the back, it is brought over the vellum and inserted into the book and out at the back, and the headband is then proceeded with as above. To finish it off, the needle end is inserted into the book twice, and the other end then pressed behind, and both are cut off, leaving short ends, which are frayed out and pasted down to the back. The ends of the vellum are then cut off.

This kind of headband would be too expensive for the cheaper bindings. In their place the leather at head and tail can be turned over a piece of string when covering.

Leather for Bindings. Various kinds of skins are used in bookbinding, chief among them being those of sheep, oxen, calves, goats, and pigs. *Sheep skins* are cheap, and, when not subjected to hard wear, last well. Those classes of skins tanned in India, and known as "Persians," both sheep and goat, have little durability. *Calf skin*, although capable of receiving a beautiful finish, does not wear well. *Ox hide* has to be reduced so much in substance to be fit for binding books that the greater part of its strength is lost. *Goat skins* furnish "Morocco" leather of several kinds. Of these, the finest is that of the Cape of Good Hope, known when finished as "Levant Cape Goat"; it has a bold, natural grain, and is perhaps the most beautiful leather for bookbinding. *Pig skin* is very durable, and is best adapted for large work. A leather which has great beauty and strength is made from the Greenland seal, but much depends on its preparation.

In cutting out the leather a piece of paper is first cut to the size of the leather required, and the leather is then cut to the size of the paper. The leather requires thinning (termed *paring*) in several places: (1) where it is turned in, to enable it to turn neatly over the edges of the boards; (2) where it will go over the back, to allow the cords to be sharply emphasised; and (3) where it will go in the joints, to enable the boards to open freely.

As there is a double thickness of leather where it is turned in on the back, it is pared especially thin there. The cover is marked in pencil to show where the paring is required, and is laid on a smooth stone and pared with a knife to the necessary degree of thinness.

Covering the Book. Before covering, the edges of the book are "capped up" to prevent damage from the paste used in the process. Two pieces of thin celluloid are placed on either side of the book itself, which is then completely covered up with paper. Small pieces are next cut from the back corners of the boards to allow for the leather being turned in there.

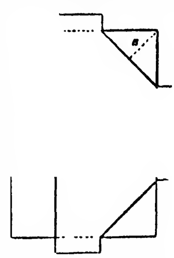
The leather is well pasted, the book, closed, is laid down in the place marked for it, and the remainder of the cover is drawn over the back and the other side. The book is then stood on its fore-edge, and the leather pressed from the back towards the fore-edge. The leather is slightly damped on the back with water, and the bands are nipped up with band-nippers. The cover is next smoothed on the sides and the leather is turned in over the fore-edges of the boards and smoothed down with the folder; finally, the cover is turned in at the head and tail.

At the corners the leather meets at an angle of 45°, and the surplus is cut off with scissors just above the board, and one edge of the leather is lapped over the other. A piece of thread is now tied tightly along the joints passing across the head and tail, and pressing the leather in where the back corners of the board have been cut away.

The bands are again nipped up, and the leather between the bands well rubbed down with a band stick. Finally, the cover is sponged over with water to remove any paste that may have got on the book, and, with a piece of paper on each side, the book is placed between a pair of pressing boards and left for at least twelve hours. When the leather is set, though not actually dry, it is trimmed on the inside of each board.

Half Binding. If the book is to be half bound, the processes are just the same up to covering, and then only the back, about one-third of the sides, and the corners are covered with leather.

The proportion between the back, corners, and the remainder of the sides can be seen in 20. The dotted lines A and B should be of the same length. When dry, the leather is trimmed straight at the back and corners, and the material for the side is cut out. This is usually either paper, cloth, or buckram. It is cut to the shape shown in 20, and then glued on, the edges being turned in over the edge of the boards. With the cheaper bindings, the corners are sometimes omitted, and it is then called a quarter binding.



20. HALF BINDING

Pasting Down Endpapers. The waste sheet is torn out and any pieces that remain in the joint are removed with a knife. The inside edge of the board is then sandpapered or scraped with a knife to remove any glue or paste that may have adhered. The width of the margin of the leather is then taken with a pair of dividers, the pasting-down paper drawn over the board, and the measurement marked off all round on the paper. A tin is then placed on the book and the paper laid down on this, cut round with a knife, and pasted down on the

board. It is rubbed down through a piece of waste paper, particular attention being paid to the joint.

Finishing and Decorating. *Tooling* is the usual method adopted for the decoration of leather bindings. It is divided into two classes —"gold tooling" and "blind tooling." Finishing tools are made in either brass or steel, and have surfaces cut in the forms of lines, dots, or engraved with pattern [12]. For long lines a fillet is used. This is a wheel with an edge cut to the thickness of the line required [7].

If an elaborate pattern is required, a thin, tough paper is used for a working pattern, slightly pasted at the corners, and placed in position on the cover. Then all the tools of which the pattern is made up are heated and stamped in through the paper. A pad of wet cotton-wool is kept close by, and the tools are used when they just cease to hiss on the wool. They are held in the right hand, and when striking, the tool is guided into its place with the thumbnail of the left hand.

If the pattern is to be in blind tooling, the leather is damped and the tools again stamped in. The heated tool coming in contact with the damp leather makes a rich, dark impression.

If the pattern is to be in gold, the leather is washed with vinegar, and when dry, the impressions are painted with glaire, very slightly diluted with vinegar. When the glaire is dry, the gold leaf is cut into pieces of a convenient size to lay on, the leather is slightly greased with a piece of cotton-wool and vaseline, and the gold is picked up with another piece of wool and laid on the pattern and firmly pressed down. The pattern should be clearly seen through the gold, and the tools are now stamped in again. When all the pattern has been impressed, the surplus gold is rubbed off, leaving just the gilded impressions of the tools.

The book is then placed in the press, with tins on the inside of the boards, and nickel plates on the outside, and slight pressure is applied; this causes the boards to close properly, and completes the binding of the book.

PUBLISHING

The publishing of books is admittedly one of the most attractive trades to which a young man can turn his attention. Even old men are tempted to set up as publishers by the general notion that it is about the most lucrative business in which one may engage. This latter is, now, a mistaken idea, whatever reason there may have been for it in the past, and certainly a review of the fortunes made in publishing would go far to support the proposition that it is a paying business. The shrewd Scotsman who founded the house of Murray in the year 1768 had been in the Navy, and was induced to turn publisher because he observed "many blockheads" were then "making fortunes" in that very pleasant occupation. Modern competition has long since made it impossible for any but the most resourceful of men to succeed in the world of publishing, and only a few businesses, which exist very largely on their old reputations, can be conducted on the easy methods of half a century ago. There is undoubtedly no room for blockheads today. In point of fact, after newspaper publishing, there are few businesses in which one can more speedily get rid of a considerable fortune than in book-publishing. To secure any substantial success, a large capital investment is absolutely essential, and this none the less when it is associated with brains and intimate knowledge of the trade.

Value of an "All-round" Experience. There is, of course, a "royal road" to publishing as to most other trades, although our moralisers may deny this. But few of us are in the position to follow the royal road, and have, instead, to take the toilsome way which, in the end, is likely to be more solidly successful, and may, on the whole, by honest endeavour, be made as pleasant. If we cannot, by paying a substantial fee to some publisher for the privilege of receiving an insight into all his departments—as so many Germans do nowadays in London—we must needs begin at the bottom of the ladder. Naturally, the earlier one enters the trade the better. We know one of the most successful of the younger publishers who practically went through every department, beginning as a shop-lad in a large wholesale firm of distributors, with his mind constantly set on becoming a book-publisher. As he had realised his ambition before he was thirty, it will be seen that, given sufficient pertinacity and resource, even the humble shop-lad may look forward to seeing his name as the imprint of thousands of books some day.

In all the leading provincial cities there are large firms of wholesale dealers in any one of which invaluable experience may be obtained, provided always that one enters their service early enough—say, from fourteen to sixteen years of age. By passing through the various departments in a large wholesale house, the Town Department, the Country, the Postal, the Stock, and other departments, a thorough knowledge of a most important side of the publishing business may be obtained. One might come somewhat later to the wholesale trade, if one had previously secured some experience in a retail booksellers' [see BOOKSELLING, page 1096], and, indeed, this would be a wise course to pursue.

The Producing of Books. But after everything has been learned, both in the wholesale and retail, there would still remain the most important knowledge of all to be acquired—namely, the manufacture of books. The bookseller and the wholesaler only come in after the publisher has done his work. It is by no means usual that one man should have experience in every detail of the trade from the producing to the selling of books, and in every publishing house in the country there are many employees who have served for years, and are content to serve, in some particular department without acquiring a general knowledge of the trade. Indeed, such men necessarily form a majority of those engaged in the business, but it is not from such that successful publishers are made, and nothing is more fatal to promotion than remaining too long in any one department.

Before turning to the consideration of the actual business of a publisher, we should point out that most valuable experience can be obtained by engaging as traveller with a wholesale house Of course, every publishing firm of any standing employs a number of travellers from whose ranks many of our most successful publishers have risen. We have preferred to mention the great wholesale houses first, as these are not confined to London, whereas, excepting a few notable firms in Edinburgh and Glasgow, there are practically no important publishing houses outside of London. The provincial youth has thus to turn his attention—in the first place, at least—to the wholesale distributors and the large booksellers, who very often do a small amount of original publishing.

London is essentially the Mecca of publishing, and the young man who is ambitious of becoming a

publisher will do well if he can secure an engagement with a London publisher when he is about twenty years of age.

The Young Publisher's Progress. Assuming that he is determined to be no mere employee in a department, but has set his mind on a managerial post at least, we shall suppose him to have had, first of all, a reasonable knowledge of English literature [see LITERATURE], and if he gives evidence of any literary taste and judgment, he will not find it difficult, after he has spent some time in the Costing Department, where he will have become familiar with the cost of producing a book and the various qualities of material used, in getting into the Production Department, the scope of which varies greatly in accordance with the importance of the firm. Here the duties consist of keeping account of all accepted MSS., arranging with the printers for specimen pages, and estimating the size of books, deciding upon the style of title-pages, bindings, general get-up, and proof reading. It is, in a word, the department in which all the practical detail of production occurs, from which the MS. of a book is handed to the printer, and from which the first completed book is handed over to the manager. In the smaller firms this department is concerned also with drawing up the spring and autumn catalogues, but in the large houses that important part of a publisher's business usually falls to the lot of the Publicity Department.

It will be gathered from our qualifying references that it is very difficult to speak of the publishing trade in general terms. There are many publishers earning a good livelihood who employ no more than half-a-dozen assistants, and unite in themselves all the different departments we have mentioned. In fact, it is no bad plan for a young man to attach himself to one of these smaller publishers, as the variety of work which will fall to his share every day will result in his acquiring a very good knowledge of the trade more speedily than it could be acquired in one of the larger firms.

The Work of the "Literary Adviser." The office routine of a large publishing house is, of course, very much the same as that of any other business, but the young man who has shown sufficient literary aptitude to be placed in the Production Department is fairly certain to be employed sooner or later in the reading of MSS., and in consultation with the manager preliminary to the acceptance of a work. The "literary adviser" used to be a somewhat mysterious person who read all the MSS. received, and supplied reports as to their literary qualities and the likelihood of their success. He was sometimes himself a distinguished novelist, who thus eked out some extra income by giving what was very frequently the most misleading advice. This old-fashioned type of adviser is disappearing. The successful publisher of to-day depends hardly at all upon the unsolicited MSS. he receives. They are read and reported on as of old, but his reader, if he himself does not do the work, is more likely to be some alert person with the real journalist's knowledge of what is calculated to interest the public, and it will be found that he or the publisher himself will be the first to think of most of the books they will publish. As a matter of fact, the ideal publisher, or literary adviser, is essentially an ideal editor. The editor of a successful magazine has a certain public, or perhaps several publics, in mind when he sits down to plan out his next number. In order to secure an attractive programme, he will ask a certain number of distinguished writers each to contribute a story of a certain kind and a given length. He will arrange so many articles to suit this section or that section of his readers, and he will ask certain writers to prepare them. He will then decide how many pages each is to occupy, including illustrations, and will carefully choose the artist who can best do the different kinds of pictures he requires. Hence, although he may receive 200 MSS. per week, he will seldom retain more than two, and nothing but the fear of missing a good article by an unknown writer induces him to wade through the MSS. Now, if for stories and articles we substitute novels and books of biography, travel, and general literature, the publisher is engaged in precisely the same work as the editor. This indicates that one may come to publishing through editing; but, of course, for such a one the SELF-EDUCATOR is hardly likely to be a guide.

"A Genius for Publishing." It is unnecessary here to dwell upon such technical details as the arrangement of a book, the various sizes of paper, types, illustrations, printing, and book-binding. All these matters are dealt with in other parts of the present course, and with them the beginner in book production must necessarily and speedily familiarise himself. In the little space that remains to us we must confine ourselves to the general aspects of publishing, and need we say that after every possible tittle of information touching the practical side of the business has been acquired, if the intending publisher is not gifted with the peculiar acumen that makes the successful editor and the prosperous publisher, he may have studied and prepared for the work in vain? There is some touch of genius in knowing just what is likely to meet the tastes of the many different sections of the public, and without this all the technical knowledge in the world will avail nothing. Every day of our life we see books being published which we know cannot possibly succeed. Sometimes this is the bad judgment of the publisher; again, it may be the foolishness of the vain writer, who has paid some publisher to issue the work, but publishers who do this never rank high in the profession.

Risky Publishing and Safe. Not very well can we lay down any rule as to the amount of capital that is required to engage in publishing. Everything will depend upon one's personal requirements and how soon a return for one's money will be expected. This, however, can be said, that cheap publishing requires by far the largest amount of capital. That is to say, to deal largely in attractive editions of non-copyright books at cheap prices involves a much greater risk than the publishing of original works in general literature, in editions of, say, one thousand copies, at good prices, from six shillings upwards; and if the possibilities of the more expensive publishing are not quite so great, the money invested is far safer and likely to produce a substantial return. Novels, and fiction of all kinds, involve a much greater element of risk than works of biography and travel; but it is an axiom of the trade that educational and technical books are of all the most desirable to publish, as they supply a demand that can be easily gauged, and if at all well done, cannot easily fail to be profitable.

BOOKS *concluded; followed by* LIBRARIES

MAN AGAINST BACTERIA

The Facts of Immunity. The Fates of Nations Decided by Bacteria. Empires Founded on Immunity to Disease. Immunity from Moral Disease

Continued from page 6544

By Dr. GERALD LEIGHTON

BEFORE proceeding to the next portion of our subject, it will be well to summarise briefly the important bacteriological facts bearing upon the causation of disease and production of immunity.

Bacteria produce their effects either by their own multiplication or by the manufacture of poisonous toxin. Some diseases, such as anthrax, are due mainly to the former process. These are termed septicæmias. Others are chiefly dangerous from the toxic action of the microbe—for example, tetanus or lockjaw. Hence, substances which prevent or cure microbic disease are either anti-bacterial or anti-toxic, according to the nature of the particular disease. Immunity is of two different types—natural or acquired. Natural immunity belongs to the individual in virtue of his being the person he is, a person of a given species, race, family, temperament, and idiosyncrasy. It is a product of evolution, and hence is found to show itself in various directions in different species and races. Because it is inborn, it can be, and is, transmitted by heredity; it cannot be transferred from one individual to another. Acquired immunity, on the other hand, comes to a person in one of two ways—either as the result of recovering from disease, or as the result of artificial inoculation. Because it is acquired, it cannot be, and is not, transmitted by heredity. But it can, by suitable methods, be transferred from one individual to another.

Disease Cured by Horse Serum.

The most perfect method of thus transmitting an acquired immunity is to be seen in the serum treatment of disease. This depends upon the fact that when a susceptible animal is artificially made to acquire immunity, the serum of that animal contains substances which are either anti-bacterial or anti-toxic. This serum can be readily withdrawn from the animal in question, can be preserved for a considerable length of time, while it retains its properties, and can thus be used at any moment when required as a curative agent. Such a serum, to be depended upon, must be taken from a highly immunised animal; it must have, in other words, a high anti-toxic value. By this is meant that a given quantity of that serum must be of such potency as will enable it to antagonise a large quantity of toxin in a patient. It is not sufficient that it merely be anti-toxic: it must be highly anti-toxic. The reason is obvious. It is impossible for the physician to estimate in a case, for example, of diphtheria, how much toxin is present in the body of his patient as the result of the action of the microbe of that disease. There may be little; there may be much. There may be little to-day, but sufficient to-morrow to kill the patient. In order that the anti-toxic serum may be reliable, it follows that the dose of that serum must contain sufficient anti-toxin to antagonise the largest quantity of toxin which is likely to be present in any case of diphtheria.

A serum of this high immunising power is obtained from the horse by rendering that animal immune, not merely from ordinary doses of diphtheria anti-toxin, but from doses which, under ordinary circumstances—that is, were the animal not immunised—would be much more than sufficient to cause a fatal result. The bacteriologist, whose business it is to prepare a serum has definite tests by which he is able to "standardise" his serum, which is therefore always of a known potency. Not only so, but he is able to increase or decrease the virulence of disease-producing microbes by various methods of cultivation, and so able to produce immunity from a more virulent microbe than the one which usually causes the disease itself.

The advantage of using a serum to confer acquired immunity is that its anti-toxic properties are available for instant service. It is a curative agent. The disadvantage of conferring an acquired immunity by a serum is that such an immunity lasts but a short time. The serum is a foreign substance, and, as such, tends to be eliminated from the system before very long. Meantime, however, it has done its work of healing. The advantage of acquiring immunity by recovery from disease is that such an acquired immunity lasts for a long period—perhaps years, perhaps a lifetime. The disadvantage of this process is that the patient has to make his own anti-toxic substance while suffering from the disease. It is therefore only of value as a preventive agent against future infection.

The Place of Bacteria in Evolution.

It is surely a wonderful thought that these microscopic bacteria contain within them the fate of nations; but such is indeed the case. It would be difficult to think of any one class of agency which has been such a potent factor in the past history of the evolution of mankind, and which is still in active operation to-day. We have seen in another part of this work [see BIOLOGY] that organic evolution means *adaptive change*, and that the most powerful factor in its production is natural selection of the fittest to survive. Any agency, therefore, which operates by eliminating huge numbers of individuals must be a most potent cause of racial evolution. In fact, the evolution of any nation is that of its immunities from the various deleterious influences to which it is subjected. Restricting ourselves for the moment to what we term the physical sphere, and in that sphere to the domain of disease, it is thus quite obvious that the evolution of a nation or a race will depend upon the evolution of immunity from various diseases, or else upon the evolution of the power of acquiring immunity. Take our own race as a case in point.

For very many generations the people in these isles have been subject to the infection of tuberculosis, or consumption. Now, the microbe of this disease, the tubercle bacillus, flourishes best in the environment of what we term "slums." In these "slums" are gathered together in dense crowds great numbers of our population. Nothing but a strong power of resistance—that is, immunity—could possibly prevent the utter extermination of people under such conditions, and, as a matter of fact, as we know, many do so perish. But why not all, or a great many more than do? Obviously, there has been evolved in our race an inborn power of resistance, an inborn immunity. How has it been

evolved? In the usual way, by natural selection of the fittest to survive. Who were the fittest in this particular case? Those who possessed by nature already some power of resistance. The others, the less resistant, have been in process of elimination for generations. Thus is gradually being evolved in our race an inborn immunity from this particular disease. If we wish to see what happens in the absence of such evolution we have only to notice the effect of this disease upon a race previously unexposed to it. Its ravages are terrible.

Measles as a National Disaster. Take another case—that of measles. Here we have a disease to which every Englishman is still susceptible, but against which, all the same, there has been great racial evolution in a different direction. Measles in this country, apart from any complications, is considered a trifling complaint. We know from experience that nearly every case will end in recovery. But when measles is introduced amongst a race to which it was previously unknown, the Polynesians, for example, its effects are so severe that a large proportion will perish. Why? Because the Englishman has undergone a process of evolution against measles of which the Polynesian has had no opportunity. But note the Englishman still gets measles. He has not evolved any immunity from infection. He is as susceptible as ever, apparently. What he has evolved is the capacity to recover—in other words, the power of acquiring immunity. How has this been accomplished?

Obviously, again, it is a question of natural selection. Once more the unfit have gone to the wall. When measles first attacked us, those individuals only who had the power of recovery and of acquiring immunity survived. This was an inborn power capable of transmission by heredity to their descendants. In this way each succeeding generation became more and more capable of acquiring immunity from measles. And this would go on as long as measles was a selective agent.

Thus, in some infectious diseases which affect large numbers of people there is evolved by natural selection an inborn immunity from infection. In other diseases there is evolved the power of acquiring immunity from the effects of the disease. These two processes are perfectly distinct, but both proceed along similar lines of evolution and are the cause of the racial differences of susceptibility to disease which we see in the world to-day.

"Modern examples of ancient epidemics," as Dr. Archdall Reid says, "may be seen in isolated regions. In Pacific islands, for example, air-borne disease spreads like a flame. The whole community is stricken down. The sick are left untended and perish in multitudes. The fields, the entire business of the community, are neglected, and famine frequently follows. Under such conditions measles or whooping-cough—diseases which we in England are accustomed to regard as scarcely more than nuisances—may rise to the level of a great national disaster. Thus, in 1749, thirty thousand natives perished of measles on the banks of the Amazon. In 1829 half the population died in Astoria. In 1846 measles committed frightful ravages in the Hudson Bay Territory. More recently a quarter of the total inhabitants was swept away in the Fiji group."

Evolution against Consumption. "The progress of consumption was different. It was never truly epidemic. Owing to its low infectivity, to its lingering nature, to the fact that no immunity from it could be acquired, it did not spread suddenly when first introduced, but when once established its virulence did not abate within measurable time. In other words, it was endemic from the beginning. It made its home in the hovels of the early settlers on the land. In such situations—as in Polynesian villages—modern Englishmen do not take the disease. But their remote ancestors were more susceptible; they could be infected by a smaller dose of bacilli. Gradually, as civilisation advanced, the conditions became more stringent; men gathered into larger and denser communities, into hamlets and villages, in which they built houses ill-lighted and worse ventilated. With the rise of towns, and ultimately of great cities, the stringency of selection continually increased, and with it, step by step, the resisting power of the race. To-day Englishmen dwell under conditions as impossible to their remote ancestors as to the modern Red Indians. In fact, no race, especially in cold and temperate climates, is now able to achieve civilisation, to dwell in dense communities, unless it has previously undergone evolution against tuberculosis.

"So during the long sweep of the ages the microbic diseases strengthened their hold on the inhabitants of the eastern hemisphere, who, in turn, slowly evolved powers of resistance. In like manner antelopes grow swift and wild sheep active when persecuted by beasts of prey. Then, when the germs of disease were rife in every home and thick on the garments of every man, there occurred the greatest event in human history, the vastest tragedy. Columbus, sailing across an untracked ocean, discovered the western hemisphere. The long separation between the inhabitants of the East and the West ended. The diseases of the Old World burst with cataclysmal results on the New."

Bacteria as Empire Builders. Then, of course, what had already happened in the Old World had all to be undergone again in the New. Once more plague and pestilence held the field, with great epidemics, followed by famine. In the same way, when smallpox was taken to the West Indies in 1507, whole tribes were exterminated, and shortly afterwards the same fell disease depopulated San Domingo. Three-and-a-half million human beings perished from it in Mexico. Catlin, in 1841, wrote of the United States, that "thirty millions of white men are now scuffling for the goods and luxuries of life over the bones of twelve millions of red men, six millions of whom have fallen victims to smallpox." And so the white man spreads over the so-called uncivilised portion of the globe and inhabits the choicest places previously occupied by others, simply because it has been his lot to have evolved in the course of ages an immunity from some infections and a power of acquiring immunity from others. So the Spanish conquest of the West Indies was followed by the rapid disappearance of the natives, who acquired the diseases imported by every vessel. The striking lesson that bacteriology teaches the empire-builder is that any conquest, in order to be permanent, must be accompanied by extermination, for otherwise, in the course of time, the native will either absorb or expel the conquerors. Dr. Reid says "The Saxon conquest of England was permanent; of the Norman conquest there remains scarcely a trace. The Huns and the Franks founded permanent empires in Europe; the Roman Empire and that of the Saracens in Spain soon tumbled into ruins. It is highly improbable, therefore, that the British will retain their hold on their Old World dependencies. A handful of aliens cannot for ever keep in subjugation large and increasing races that yearly become more intelligent and insistent in their demands for self-government. But no probable conjunction of

circumstances can be thought of that will uproot the Anglo-Saxons from their wide possession in the New World. The wars of extermination are ceasing with the spread of civilisation. We have ransacked the world, and now know every important disease. Diseases cannot come to us as they came to our forefathers and to the Red Indians, like visitations from on high. All the diseases that are capable of travelling have nearly reached their limits; the rest we are able to check. Even in the unlikely event of a new disease arising it would affect other races equally. Canada and Australasia, like the United States, may separate from the parent stem, but the race will persist. If ever a New Zealander broods over the ruin of London he will be a New Zealander of British descent."

New Empires no longer Possible. Thus in plain fact is the natural history of man nothing more than the story of his evolution against bacterial diseases. It is a humbling thought but a true one that the conscious efforts of man have had but little influence upon his destiny in comparison with his unconscious struggle to evolve against the most minute of living creatures. The time for founding new empires has gone for ever. Only a few malarious districts remain. Other nations had their opportunity and threw it away by choosing the tropics for their empire instead of the temperate climes, as was the case with Spain and Portugal. "France lost her opportunity on the Heights of Abraham. Germany is more than a century too late in the start. Russia can conquer only hardy aliens, who will multiply under her rule and ultimately assert their supremacy." To Great Britain alone was it given early enough to evolve immunity from the most devastating of bacterial diseases, and the wisdom or good fortune to colonise those portions of the world where this advantage placed the land at her mercy.

In this brief survey of modern bacteriology we have seen the dawn of a revolution in the methods of medical treatment of disease, a revolution whose future results it is impossible to foresee. In the future of bacteriology lies the hope of the healing art. We have seen how bacteria have moulded the history of the world and particularly of our own race. It only remains to show that these same great principles are in operation in other spheres than those of bacteriology, and that the laws of immunity have a far wider application than has hitherto been supposed. The greatest discovery of all is made plain by the discovery of the laws of immunity in bacteriology—namely, the fact that these laws are operative also in the mental, moral, and religious life of man, as well as in his physical body.

THE HIGHEST AIM OF MAN, PHYSICAL AND MORAL

A great number of readers have now followed the present writer in the sections of this work dealing with the sciences of biology and bacteriology. In the former of these courses we studied the problem of organic evolution, and endeavoured to gain some clear idea as to how that evolution had come about. We watched the relentless principle of natural selection at work, selecting the fit in the struggle for existence and rejecting the unfit, the suppression of the individual for the good of the race. That is Nature's method of progress. Then in the course of bacteriology we have studied a special aspect of organic evolution, evolution against microbic disease, and realised something of what has taken place in past ages which makes it possible for modern civilisation to exist as we see it in our teeming cities. We have learnt that it is possible for a race to become immune from a disease, and for an individual to possess the power of acquiring immunity. More, we clearly see that, unless evolution produces individuals who are either immune, or can acquire immunity from disease, the nation composed of those individuals *must inevitably perish*.

Evolution Against Moral Disease. In what follows here the writer wishes to apply these same principles and laws to other phases of man's life, to show what, in his opinion, must constitute the scientific base of evolution in other spheres than those of disease—spheres to which, as far as he is aware, these laws have not been definitely applied. The view to be here stated is given with all humility; it will not appeal to all—no view can do that, because a hundred minds see the *same truth* from a hundred different aspects—but it is hoped that, as it has helped a few already, it may be of assistance to many more in showing that there is solid scientific ground for expecting certain definite results to follow equally definite lines of procedure in other parts of man's nature.

It will be taken for granted in what follows that the reader has made himself familiar with what is meant by "Immunity," and that he has clearly understood the two types of immunity described in BACTERIOLOGY under the names "Natural or Inborn Immunity" and "Acquired Immunity." It must also be clearly understood that we are not here attempting to construct an elaborate analogy. An analogy is a likeness between things in some respects when the things are otherwise entirely different. The attempt here is to apply the same *identical laws* to additional aspects of man's nature.

Wider Application of Laws of Immunity. If the laws of immunity mean anything, they convey the greatest truth in the world—namely, that by undergoing certain processes a man can become immune from certain agencies. This is the highest aim of man. Physically, mentally, morally, he who is immune from all that can work him evil is the perfect man. There can be no higher ideal for man than to become immune from all that will interfere with the perfect development of his physical, intellectual, and moral nature.

Therefore, we say advisedly that the laws which govern the production of immunity convey the greatest truth in the world. What is here advanced is the scientific application of those same laws of immunity in disease to other parts of man's nature. Disease is merely one phase of human life, and is not entirely physical. It has its mental and moral aspects. We therefore assume that these aspects are involved in the working out of immunity. It is contended that the mental and moral processes, as well as those of disease, can be explained, and their nature demonstrated, by the application of the well-known laws of immunity to that part of man's nature of which they are the outward expression. One cannot separate these from the rest of a man. They are just as much a part of him as is his bodily health. Just as the latter is first developed, and subsequently modified by various natural agencies, so we must believe that these mental and moral processes are similarly brought forth and modified. In a word, a man has been what he was, is what he now is, can be what he hopes to be, in virtue only of one great set of principles which we know as the laws of immunity.

We may now examine the facts of immunity in the non-physical world, just as we did in the course on BACTERIOLOGY in relation to disease. In the realm of moral disease the definition of the term would be as follows: Immunity is that condition of an individual in virtue of which he is able, either partially or absolutely, to resist temptation.

Immunity from Temptation. A close examination of the lives of men and women around us will soon make clear the fact that all have some power of resistance to the variety of moral infections—that is, temptations—by which they are surrounded, and to which they are continually exposed. If this were not so, all would be hopelessly immoral. The righteous and sober life would be impossible. Now, this capacity for resistance, which all possess more or less, is inborn, and, like that against disease, it varies immensely in different individuals. It also varies with the nature of the infection in the same individuals. The temptations of one man are not necessarily those of another, any more than are the weak points in his physical armour. Everyone knows that there are people who can, by virtue of this power of natural resistance, pass unscathed through certain moral infections which in others would inevitably produce moral death. Thus some are naturally sober, innately resistant to the special infection of alcohol. It is no credit to them, but it is something for which they should be profoundly thankful. Others are naturally honest; the temptation to steal simply does not touch them. On the other hand, there are individuals who are especially susceptible to one or other of what we term vices, in whom, that is to say, this natural power of resistance is lacking.

The next point to note is that this inborn immunity of the individual cannot be transferred from one to another. It is useless as a help to his fellow-man. It is only the man of like passions and susceptibilities as ourselves who, having become immune, can transfer his immunity to others. The person who has been vaccinated can provide vaccine lymph which can be used as a protection to others: but if he be insusceptible to vaccination by nature, he is useless for this purpose. So it is that some are born saints, so to speak, while others are born susceptible to moral infection.

In addition to this universal resistance, which all possess in varying degrees, we observe that after passing through some special temptations the individual has acquired an immunity from that special condition, an immunity which did not exist before passing through the experience in question. If the law operates here as it does in the case of disease, we should expect to find that this special immunity lasts in some cases for years, in others for a lifetime. So it is.

The Fallacy of "Sowing Wild Oats." The thought then occurs that since experience of temptations and sin (infection and disease) successfully overcome (recovery) may confer immunity, why not try and confer this immunity artificially by exposing individuals to the contagion? There are those who believe in the efficacy of this process, and who think it a good thing that "wild oats should be sown" in the hope of reaping immunity. But it must be remembered that those who are thus exposed to moral infection run the risk of moral death for themselves, and, for the time being, are centres of infection for others. As a simple matter of fact, experience teaches that large numbers who try the process die morally under its poisonous action. In the case of disease we saw that this deliberate exposure to infection on the chance of recovery with immunity has been made illegal. It is too dangerous, both for the individual and the community. Too many will perish. Only those of high natural resistance will survive. The process is effective in eliminating the unfit, and it is Nature's method, but it is too cruel. In the same way, and for the same reason, the moral and religious law steps in, and says to the individual "Thou shalt not!"

Finally there comes the tremendous claim made by the founders of all moral systems—the claim that they can confer upon mankind an artificial immunity from the moral infection of temptation and the moral disease of sin. The claim is not put in these words, but, translated into modern science, and expressed in terms of immunity, that is what it means. The modern physician is not content to trust to the chance of his patient's recovery to make him immune. The risk is too great. The moral teacher likewise sees the danger of such a process. The physician urges upon his patient not to wait until he be exposed to infection, but to protect himself beforehand by acquiring an artificial immunity. The moral teacher takes the same line, and offers a method of treatment which he claims will confer upon the person an acquired immunity for a time. True, the effect is temporary. All artificial immunity is so, more or less. But the supply is inexhaustible, the process safe, the result certain.

Immunity from Alcoholism. To make all this perfectly clear we may take one concrete example—that of alcohol. Some people have a marked degree of natural inborn immunity from the temptation or the effect of alcohol. They constitute the great majority of the sober members of the population. They are sober because they are immune. If any habitually sober man imagines that he is so because of his strong efforts to struggle against the temptation of alcohol every hour of his life, he deceives himself. It is not so. The sober man who is at the same time honest will admit, if he thinks, that to him alcohol is no temptation. He is immune. The present writer has asked hundreds of sober men why they were so, and every one, after consideration, has admitted the truth of the above statement. To most of us, therefore, it is no credit to be sober, but it should be a matter of great thankfulness that we are naturally immune.

Of those who are naturally susceptible or who acquire a taste for alcohol, a certain number in time become immune. But it is after such an experience as few would care to risk. It is a test under which most succumb, and is far too dangerous to be made a routine process. All moral and religious teachers have clearly recognised this, and they therefore offer a method of acquiring immunity which they claim to be safe, speedy, and certain. They claim that the power of the influence which they prescribe is so strong that it will protect not merely from one, but from all moral infection. In this one point they go beyond anything that science has yet discovered in the sphere of infection disease; but in every other detail the offer which they make appears to be perfectly scientific and practical. It is the method which we ourselves adopt in dealing with our fellow-men. It is the only method by which man can become immune from all deleterious influences, mental, moral, or physical.

BACTERIOLOGY *concluded; followed by* NATURAL PRODUCTS

GAS, OIL, AND PETROL ENGINES

Group 24
PRIME MOVERS
10

Continued from page 6648

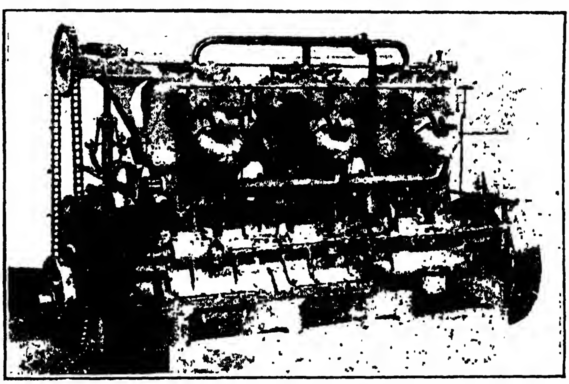
The Gas Engine. Cycles. Gases. Oil Engines. The Diesel. Petrol Motors. Thornycroft. Daimler

By JOSEPH G. HORNER

GAS, oil, and petrol engines are all classed as internal combustion engines, because the fuel is burned within the cylinder instead of in a boiler separate therefrom. Though the heat problems involved are similar to those of steam-engines, the practical working conditions are different in many details. In each case the effect of heat is expansion and pressure, but the pressure of the elastic fluid steam is not of so violent a character as that in the gas-engine. In the latter, an explosive mixture of gas with atmospheric air in certain definite proportions is made and ignited, and so exploded. The resulting heat is so intense that the cylinder would become rapidly overheated unless it were water-jacketed. This, of course, entails much loss of heat, and is exactly contrary to that which exists in steam-engine practice, in which the cylinder is jacketed to lessen escape of heat. Yet the heat efficiency of the gas-engine is greater than that of the steam-engine, because there is no loss consequent on the use of a steam-boiler, and the fuel is therefore used directly.

The term "gas" covers a wide range of product, from town's gas and producer-gas to blast-furnace waste and Mond gas. The only difference in the gas, and the oil and petrol engines, is that the first is all ready for use, and the two last have to be gasified.

Cycles. A cycle means the entire series of operations involved in the utilisation of a given charge from the period of its introduction to discharge or exhaust. The Otto cycle is that which is now nearly always used. It includes the drawing in of the gas and air into the cylinder, following behind one stroke of the piston, the compression of the mixed charge during the return stroke, and firing at the termination of the in-stroke. It is burnt and exploded in the next forward stroke. There is thus only one actual working stroke in four in an Otto single-acting engine; but further economy is ensured by governing on the hit-and-miss principle. The governor opens or closes the gas valve, responsive to the load on the engine. Most large engines, however, are now often governed in another way, by varying the volume of the gas admitted. The amount of compression possible varies with different gases from about 4 atmospheres to 10, being dependent on the proportion of hydrogen present. The larger the proportion of hydrogen, the less compression is possible. Ignition is effected by an electric spark, or by a red-hot tube.

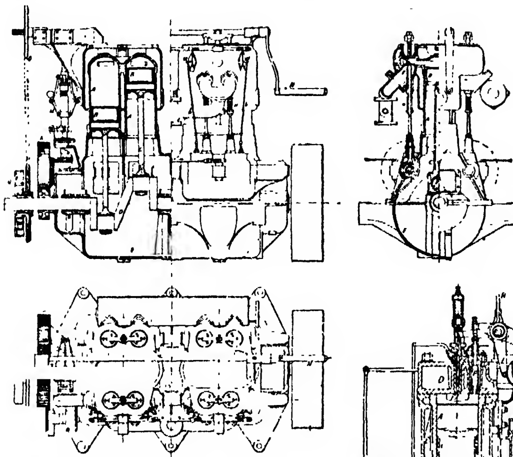


82. 78-B.H.P. PETROL ENGINE FOR MARINE USE
(John I. Thornycroft & Co., Ltd.)

Gases. The gases used vary much in calorific or heat-giving power. Town's gas alone was used in the early days of the gas-engine. It has a higher percentage of heat-giving power than any other; but its use has long been discarded for large engines in favour of gases lower in calorific power, but much cheaper. The calorific capacity of producer gas is only about one-fourth that of retort gas, that of Mond gas about the same, while that of blast-furnace gas is only about one-sixth. But the nitrogen in the latter takes the place of much of the air ordinarily required in retort gas, and hence the engine efficiency is higher than the calorific value of the gas alone would indicate. In the gas producers, fuel generally of a cheap and inferior kind is fed from a hopper to a brick-lined cylindrical vessel containing a grate. Air is fed by a fan, and carbonic oxide is formed, with nitrogen and other elements in various proportions, according as the method adopted is dry, or wet, or water-gas.

Blast-furnace Gas. Nothing has given so much impetus to the growth of the large gas-engine as the utilisation of blast-furnace gas. The first large engine of this kind exhibited was at the Paris Exhibition of 1900, being of about 600-h.p., which has been more than doubled since. As long as town gas or Dowson producer gas were the only sources available, engines of over 100-h.p. were rarely made. The space occupied by generating plant, and the cost, did not compare very favourably with the steam-boiler plant. In the development of these vast engines, the Cockerill Co., of Belgium, and some German firms led the way. The result is that these engines are now scarcely discernible from steam-engines in external appearance; they are double-acting, and the valves of the drop type resemble those of steam-engines. The hit-and-miss regulation is abandoned in favour of a governor-actuated cam, which regulates the amount of lift of the gas valve, besides which, an immense number of special details are included. At Oberhausen there are seven double-acting engines of this kind, four of which are 1,000-h.p. By designing engines tandem, with two, or four cylinders, the power is multiplied; so that there are engines of 2,000-h.p. and over at work, and there is no reason why from 5,000-h.p. to 6,000-h.p. should

not be made if required. In the early days of blast-furnace gas-engines, much trouble arose from the presence of dust and of tar. The dust is now readily got rid of, but the tar still causes trouble, lodging in the cylinder and causing the valves and piston rings to stick in their seatings.



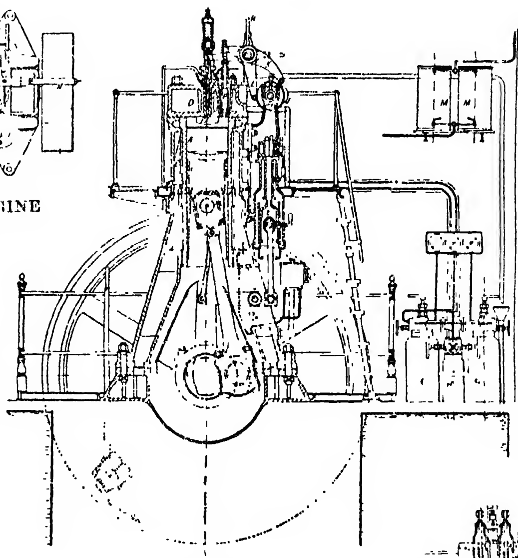
93. THORNYCROFT ENGINE

Oil-engines. These are gas-engines to which the fuel is supplied in the liquid form. Their value lies chiefly in isolated districts in which no power-gas is available. Ordinary petroleum is generally used. The oil is introduced in definite volume into a highly heated chamber—the vaporiser—along with a suitable supply of air. The mixture is then drawn into the working cylinder by the suction stroke. It is then compressed on the return or in-stroke, and ignited. The explosion gives the working stroke, and in the return stroke the products of combustion are exhausted, thus embodying the Otto cycle. The governor lessens the number of explosions when the engine is running light. In some engines the oil is sprayed and mixed with air before it is passed into the working cylinder to be compressed. In others the air is compressed in the vaporiser. The charge of oil and air when it enters the cylinder should have a temperature of from 170° F. to 300° F. About 1 lb. of oil is required per brake horse-power per hour. Petroleum suitable for engines should have a specific gravity of 0·8, and 150° F. its flash point. Cylinders are jacketed as in gas-engines. The thermal efficiency of oil-engines ranges between about 12 per cent. and 18 per cent., the latter being high. By thermal efficiency is meant the ratio of the actual work done by the engine at the brake (B.H.P.) in a given time to the total heat supplied per minute by the complete combustion of the oil required to do that work. Or,

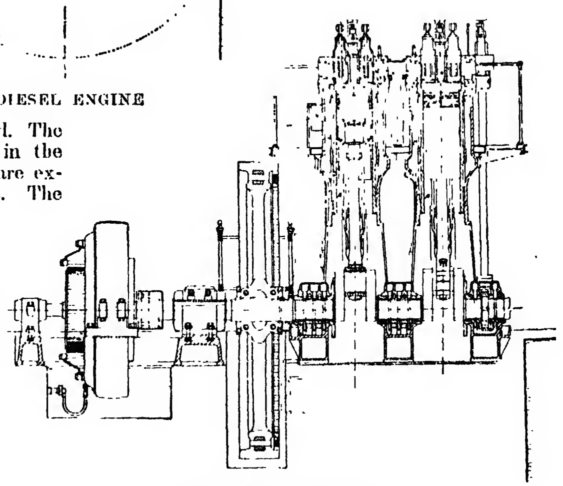
$$\text{Thermal efficiency} = \frac{\text{work done per minute}}{\text{heat supplied per B.H.P. per minute}}$$

One-horse power = 33,000 foot-pounds per minute, or 42·63 heat units. The heat unit is the quantity of heat required to raise the temperature of 1 lb. of water through 1° F., and is equivalent to 774 foot-pounds.

The Diesel Engine. This [94 and 95] is a remarkable type of oil-engine which has been developed rapidly of late years. The leading feature by which it is distinguished is the very high compression and temperature employed, from which various results follow. It operates upon the four-cycle principle. During the first stroke air alone is drawn into the cylinder at atmospheric pressure and temperature, and this charge of air only is compressed on the return stroke, to a pressure of about 32 to 35 atmospheres, or, say, 450 lb. to 500 lb. per square inch with a temperature of about 1,000° F. During the third or working stroke the oil fuel is gradually injected by means of an air jet at a pressure of about 800 lb. per square inch. The effect is to spray the oil very finely throughout the highly heated charge of air, with which it is ignited, in consequence of the high pressure present, no ignition apparatus being necessary. There is, therefore, no sudden explosion, such as that which occurs in the ordinary oil-engine,



94. DIESEL ENGINE

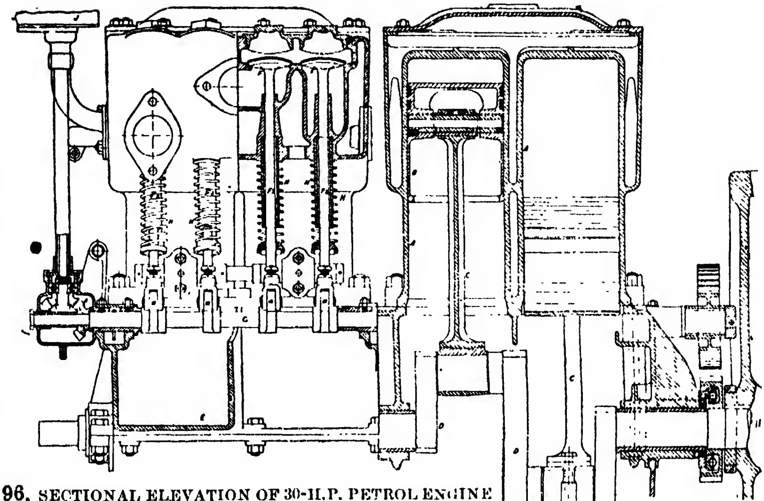


95. DIESEL ENGINE

but a gradual combustion and gradual expansion without shock. The fourth stroke exhausts the products of combustion.

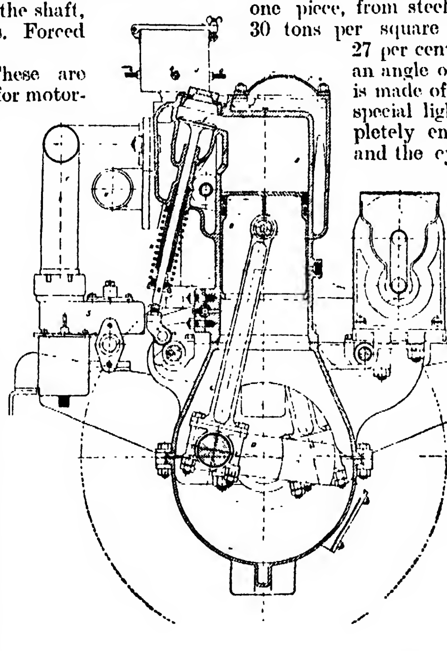
In the illustrations [94 and 95], which is an engine by the Vereinigte Maschinenfabrik Augsburg und Maschinenbaugesellschaft Nürnberg A.G., Augsburg, the following are the principal parts of the engine:

The cylinder A is fitted with a water-jacket B; the piston C is of trunk form; the engine cover D is at the head of the cylinder, and is also water-jacketed; E is the air pump; N is the fuel feed pump. The compressed air is stored in the vessels G, G, H, one of G being a reserve. The fuel is received from the filtering tanks M, M, and brought into the fuel valve F above the cylinder by means of the pump N. The other valves are the starting valve P, the exhaust valve O, and the air pump suction valve Q. By means of the handle R the reversing lever is placed in the starting position F. After opening the valve on vessel G the motor starts running. If it has reached the speed required for igniting the fuel, the reversing lever is placed in working position, and then the engine works with fuel and may be loaded at once. The valves are all operated by cam plates on the shaft, J, K and L being the levers. Forced lubrication is adopted.



96. SECTIONAL ELEVATION OF 30-H.P. PETROL ENGINE
(Daimler Motor Co., Ltd.)

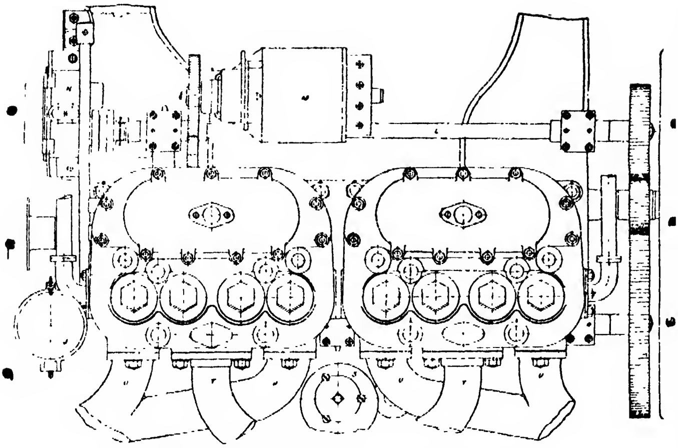
Petrol Motors. These are special types of oil-engines for motor-cars, launches, and other purposes, in which petrol, vapour and air form the combustible mixture. They are made in four and two-stroke cycle types. The first-named is the same as that already explained. In the second the operations are as follows: The mixture of petrol vapour and air is first drawn into the crank chamber, or into a separate pump cylinder. It is compressed to about 5 lb. per square inch, and is introduced into the cylinder at about the period of the termination of the out-stroke. It is compressed by the in-stroke, and is ignited by an electric spark. The charge expands and drives the piston outwards, and the products of combustion escape through ports in the cylinder walls. The two-stroke design has the advantage of simplicity of construction, but consumes more fuel than the four-stroke cycle does. The heat generated is probably about 1,800° F., which renders water-jacketing or air cooling necessary.



97. END SECTIONAL ELEVATION OF 30-H.P. ENGINE
(Daimler Motor Co., Ltd)

Figure 98 illustrates one of the petrol engines by Messrs. John I. Thornycroft & Co., Ltd., of Chiswick, for marine use. Many details which are not shown here may be observed in the photograph [92], of an engine of similar type, but having six cylinders. The drawing shows a 6 in. by 8 in. cylinder engine. In this, A indicates the cylinders, water-jacketed; B the trunk pistons, with spring rings; C the connecting rods, which are steel stampings; D the crankshaft, machined from one piece, from steel having a tensile strength of 30 tons per square inch, with an elongation of 27 per cent. The crankpins are set at an angle of 180°. The crank casing E is made of cast iron, or aluminium when special lightness is required. It is completely enclosed, is fitted with doors, and the cylinders are registered into and bolted on it. Lubrication of this engine is of the splash system, but a pump and forced lubrication is often adopted.

In front of the photograph [92], and at the lower right-hand end the carburetter is seen, with the air inlet and throttle leading to the supply pipes to the cylinders. The carburetter consists of a body in which the incoming air, as it is sucked by the motor, rushes past a nozzle, from which the petrol is drawn out in a spray and, volatilising, passes thence through the throttle. In F is the inlet pipe to the cylinder, and G is the inlet valve. The exhaust valves are on the opposite side of the cylinders (compare with the plan view). The valve rods H are actuated from the cam shafts J, operating hard steel rollers on the tappet shafts. These cam shafts are driven from the crankshaft through the gears K, K, from the smaller gear L on the crankshaft, and open and close the valves once for each two revolutions of the flywheel. The valves B are lifted by the cams against the pressure of the springs seen encircling the rods, which springs

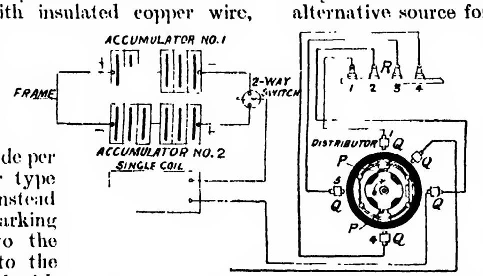


98. PLAN OF 30-H.P. PETROL ENGINE

close the valves after the full of the cam has passed. From one of the cam shafts the governor M is driven through bevel wheels. The method of its connection with the throttle, on which it acts directly, is seen in the photograph. The method of firing is by means of a low-tension magneto system. The permanent magnets are seen at the left-hand end of the photograph, just below and in front of the governor. The lower ends of the magnets carry two pole-pieces. Within these there is a fixed armature, and between them a soft iron shield or sleeve rotates. The sleeve has two slots cut in it at opposite sides, leaving two open spaces of about 90°. The armature is wound with insulated copper wire, and the lines of force that cut the armature coils vary from nothing to maximum, and maximum to nothing twice in a revolution. Four sparks are thus made per revolution. In another type the armature rotates instead of the shield. The sparking plugs are screwed into the cylinders at *a*, close to the inlet chamber, connected with the magneto by the wires *b*. A contact-breaker placed close to each plug is operated by a cam and a vertical rod. N is the starting handle connecting its shaft with the crankshaft by pitch chain passing over wheels O, P. Q is the free-wheel clutch. It is composed of a pair of ratchets which are carried on the casing round the clutch, and which in its turn is connected to the crankshaft of the engine. The starting chain wheel is attached to the ratchet wheel, which engages with the ratchets in one direction only. When it is desired to start the motor, the starting handle, and consequently the chain wheel, is turned, and drives the crankshaft by means of the ratchet wheel and ratchets. As soon as the engine fires the crankshaft outruns the chain wheel, and centrifugal action causes the ratchets to fly out of contact with the ratchet wheel. The starting handle thus becomes stationary, and the ratchets being out of contact with the wheel, there is no noise caused by their rubbing over the teeth.

A 30-h.p. Daimler motor, designed for a car (Daimler Motor Co., Ltd., Coventry), is shown in **96, 97** and **98,** lettered as follows: A indicates the cylinders, B the pistons, C the connecting rod, D the crankshaft, and E the base chamber. S indicates the vaporiser, T the vapour pipe leading to the induction ports of the cylinders, and U the pipe for carrying away the exhaust gases.

It will be observed that the cylinders are cast in pairs, and water-jacketed. The connecting rods are of H section, and the crank chamber is cast in aluminium. The induction and exhaust valves—which are interchangeable—are indicated at F1 and F2 respectively, and are actuated by the cam shaft G and tappet and roller *a*, the spring H pulling the valve down on to its seating as the cam projection passes the roller *a*. The cam shaft is driven by the usual half-speed wheels. On the side of the cylinders, opposite to and running parallel with the cam shaft, is the lay shaft L, which drives the magneto M and the gear pump N. It may be mentioned that the magneto is fitted as an alternative source for the supply of current to the sparking plugs, and is entirely independent of the ordinary high-tension circuit with induction coil and accumulators as depicted in **99**, which illustrates the method of wiring; also the plan of the distributor case J with the cover removed, showing the block O, which is in contact with and rotates between the brushes P, and thereby makes and breaks the low-tension or primary current. The distributor block O is so designed that the distribution of the secondary or high-tension current to the insulated plugs Q, and thence to the sparking plugs R, synchronises with the opening and closing of the primary or low-tension circuit. The distributor case, which, under normal conditions, is stationary, can, for the purpose of advancing and retarding the timing of the spark, be rotated on its own axis through the required angle. The vertical shaft, to which the distributor block is keyed, is driven by means of bevel gears, K, K, off the end of the cam shaft. Ball bearings are fitted at each end of the vertical shaft. The approximate weight of the above-described engine is 6 cwt.



99. PLAN OF WIRING FOR ACCUMULATOR IGNITION (Daimler Motor Co., Ltd.)

PRIME MOVERS *concluded; followed by* STEAM BOILERS

continued from page 6628

SOLUTION OF TRIANGLES

The Ambiguous Case. Worked Examples Illustrating the Four Cases. List of Text-books

By HERBERT J. ALLPORT, M.A.

44. Case Two of Solution of Triangles. Given one side and two angles, say a, B, and C. Since the three angles of a triangle equal 180°, we have $A = 180° - B - C$.

Again, $\frac{\sin A}{a} = \frac{\sin B}{b}$, so that $b = \frac{a \cdot \sin B}{\sin A}$.

Similarly, $c = \frac{a \cdot \sin C}{\sin A}$.

These two equations give the values of b and c.

Adapting these formulæ to the use of logarithms, we have

$$\log b = \log \frac{a \cdot \sin B}{\sin A}$$
$$= \log a + \log \sin B - \log \sin A$$
$$= \log a + (L \sin B - 10) - (L \sin A - 10)$$

or, $\log b = \log a + L \sin B - L \sin A$.

Similarly,

$$\log c = \log a + L \sin C - L \sin A.$$

45. Case Three of Solution of Triangles. Given two sides and the included angle, say b, c, and A. We have $B + C = 180° - A$, which gives the value of $(B + C)$. Then, from Article **40**,

$$\tan \frac{B - C}{2} = \frac{b - c}{b + c} \cdot \cot \frac{A}{2}.$$

This gives the value of $\frac{B - C}{2}$, and therefore of $(B - C)$. Having obtained the values of $(B + C)$ and $(B - C)$, the values of B and C can be found.

Finally, since $\frac{a}{\sin A} = \frac{b}{\sin B}$, or $a = \frac{b \cdot \sin A}{\sin B}$, we obtain the value of a.

To arrange the method for logarithmic work we proceed thus:

$$\tan \frac{B - C}{2} = \frac{b - c}{b + c} \cdot \cot \frac{A}{2}.$$

$$\therefore \log \tan \frac{B - C}{2}$$
$$= \log (b - c) - \log (b + c) + \log \cot \frac{A}{2};$$

or, adding 10 to each side of the equation,

$$L \tan \frac{B - C}{2} = \log (b - c) - \log (b + c) + L \cot \frac{A}{2}.$$

And, as in Article **44**, from $a = \frac{b \cdot \sin A}{\sin B}$, we get

$$\log a = \log b + L \sin A - L \sin B.$$

46. Case Four of Solution of Triangles. Given two sides and the angle opposite one of them, say b, c, and B.

Since, $\frac{\sin C}{c} = \frac{\sin B}{b}$,

$$\therefore \sin C = \frac{c \cdot \sin B}{b}. \quad . \quad . \quad . \quad (1)$$

C can be found from this equation. Then, having found C,

$$A = 180° - B - C.$$

The value of a is found, as in the last article, from the formula $a = \frac{b \cdot \sin A}{\sin B}$.

47. The Ambiguous Case. In the case considered in Article **46**, the solution of equation (1) gives the value of the *sine* of C. Now, when C is an angle of a triangle, and the value of *sin* C is known, C itself may have *two* values, one of them being less than 90°, and the other being between 90° and 180°.

Hence, there *may* be *two* triangles in which b, c, and B have the given magnitudes. Whether this is so may be decided as follows:

1. If B (the given angle) is *greater than* 90°, C must be *less than* 90°, since any two angles of a triangle must be together less than two right angles. Therefore, when B is greater than 90°, there is only one triangle which satisfies the given conditions.

2. When B (the given angle) is less than 90°, four things have to be considered.

(i.) Is b less than $c \cdot \sin B$? If so, then, since $\sin C = \frac{c \cdot \sin B}{b}$, the value of sin C is greater than 1, which is impossible [Art. **15**]. In this case there is *no* triangle which satisfies the given conditions.

(ii.) b may be *equal* to $c \cdot \sin B$. We should then have $\sin C = 1$, and therefore $C = 90°$. In this case, then, there is only *one* triangle.

(iii.) If b is greater than $c \cdot \sin B$, but *less than* c, then B is less than C [Geometry, *Prop.* 21], and therefore C may be acute or obtuse. Hence, C may have either of the values found from the equation $\sin C = \frac{c \cdot \sin B}{b}$, and there will then be *two* triangles satisfying the given conditions. This is the *ambiguous case* in the solution of triangles.

(iv.) If b is equal to or greater than c, then B is equal to or greater than C. Hence, C must be an acute angle, and therefore there is again only one triangle satisfying the given conditions.

48. We shall conclude with examples illustrating each case in the solution of triangles.

Example 1. Given that $a = 40$, $b = 51$, $c = 43$,

$$\log 2 \doteq \cdot 3010300, \quad \log 3 = \cdot 4771213,$$
$$\log 67 = 1 \cdot 8260747.$$
$$L \tan 24° \, 44' \, 13'' = 9 \cdot 6634464, \text{ find A.}$$

Here, $a+b+c=40+51+43=134$.

$\therefore s=67,\ s-a=27,\ s-b=16,\ s-c=24$

$$\therefore \text{L}\tan\frac{\text{A}}{2}-10$$
$$=\tfrac{1}{2}\{\log 16+\log 24-\log 67-\log 27\}$$
$$=\tfrac{1}{2}\{\log 2^4+\log 3+\log 2^3-\log 67-\log 3^3\}$$
$$=\tfrac{1}{2}\{4\log 2+\log 3+3\log 2-\log 67-3\log 3\}$$
$$=\tfrac{1}{2}\{7\log 2-2\log 3-\log 67\}$$
$$=\tfrac{1}{2}\{2{\cdot}1072100-{\cdot}9542426-1{\cdot}8260747\}$$
$$=\tfrac{1}{2}\{2{\cdot}1072100-2{\cdot}7803173\}$$
$$=-\tfrac{1}{2}\{{\cdot}6731073\}=-{\cdot}3365536=\bar{1}{\cdot}6634464.$$

$$\therefore \text{L}\tan\frac{\text{A}}{2}=9{\cdot}6634464$$
$$=\text{L}\tan 24^\circ\,44'\,13''.$$
$$\therefore \text{A}=2\times(24^\circ\,44'\,13'')=\underline{49^\circ\,28'\,26''.}$$

Example 2. In the triangle ABC, the base AB is 1,000 ft. long, and the angles at A and B are 31° 20′ and 125° 19′ respectively. Find the length of AC.

We are given A, B, and c.

First, $\text{C}=180^\circ-31^\circ\,20'-125^\circ\,19'$
$=23^\circ\,21'.$

Again,

$$\log b=\log c+\text{L}\sin\text{B}-\text{L}\sin\text{C}$$
$$=\log 1000+\text{L}\sin 125^\circ\,19'-\text{L}\sin 23^\circ\,21'$$
$$=\log 1000+\text{L}\sin 54^\circ\,41'-\text{L}\sin 23^\circ\,21'$$
$$=3+9{\cdot}9116739-9{\cdot}5980754$$
$$=3{\cdot}3135985$$
$$=\log 2058{\cdot}725.$$

Thus, $\text{AC}=\underline{2058{\cdot}725\text{ ft.}}$

Example 3. Two sides of a triangle being 2265·4 ft. and 1779 ft., and the included angle being 58° 17′, find the remaining angles of the triangle.

Suppose $b=2265{\cdot}4$, $c=1779$, and $\text{A}=58^\circ\,17'$.

Then, $\text{B}+\text{C}=180^\circ-58^\circ\,17'=121^\circ\,43'.$

Again, $\text{L}\tan\dfrac{\text{B}-\text{C}}{2}$

$$=\log(b-c)-\log(b+c)+\text{L}\cot\frac{\text{A}}{2}$$
$$=\log 486{\cdot}4-\log 4044{\cdot}4+\text{L}\cot 29^\circ\,8'\,30''$$
$$=2{\cdot}6869936-3{\cdot}6068541+10{\cdot}2537195$$
$$=9{\cdot}3338590$$
$$=\text{L}\tan 12^\circ\,10'\,21''.$$

$$\therefore \frac{\text{B}-\text{C}}{2}=12^\circ\,10'\,21''$$

and $(\text{B}-\text{C})=24^\circ\,20'\,42''.$

But $(\text{B}+\text{C})=121^\circ\,43'.$

$\therefore 2\text{B}=146^\circ\,3'\,42''$

and $2\text{C}=97^\circ\,22'\,18''.$

Hence, $\left.\begin{aligned}\text{B}&=73^\circ\,1'\,51''\\ \text{C}&=48^\circ\,41'\,9''\end{aligned}\right\}$ *Ans.*

Example 4. The lengths of two sides of a triangle are 5374·5 ft. and 1586·6 ft.; the angle opposite to the shorter side is 15° 11′. Calculate the other angles of the triangle, or of the triangles, if there are two.

Suppose $b=1586{\cdot}6$ ft., $c=5374{\cdot}5$ ft., and $\text{B}=15^\circ\,11'$. Then,

$$\text{L}\sin\text{C}=\log c+\text{L}\sin\text{B}-\log b$$
$$=\log 5374{\cdot}5+\text{L}\sin 15^\circ\,11'-\log 1586{\cdot}6$$
$$=3{\cdot}7303381+9{\cdot}4181495-3{\cdot}2004674$$
$$=9{\cdot}9480202$$
$$=\text{L}\sin 62^\circ\,31'\,23''.$$

$\therefore \text{C}=62^\circ\,31'\,23''$,

or $180^\circ-62^\circ\,31'\,23''=117^\circ\,28'\,37''.$

And b is less than c, therefore both these values are admissible.

Thus there are two triangles.

(i.) $\text{B}=15^\circ\,11'$, $\text{C}=62^\circ\,31'\,23''$, so that $\text{A}=102^\circ\,17'\,37''$.

(ii.) $\text{B}=15^\circ\,11'$, $\text{C}=117^\circ\,28'\,37''$, $\text{A}=47^\circ\,20'\,23''$.

Example 5.

Given that $\text{C}=52^\circ\,10'$, $b=643$ yd., $c=872$ yd., find the other angles.

$$\text{L}\sin\text{B}=\log b+\text{L}\sin\text{C}-\log c$$
$$=\log 643+\text{L}\sin 52^\circ\,10'-\log 872$$
$$=2{\cdot}8082110+9{\cdot}8975162-2{\cdot}9405165$$
$$=9{\cdot}7652107$$
$$=\text{L}\sin 35^\circ\,37'\,7''.$$

$\therefore \text{B}=35^\circ\,37'\,7''$,

or, $180^\circ-35^\circ\,37'\,7''=144^\circ\,22'\,53''.$

But b is less than c, therefore B must be less than C. Hence, the second value found for B is inadmissible.

Thus $\text{B}=35^\circ\,37'\,7''$, and

$\text{A}=180^\circ-35^\circ\,37'\,7''-52^\circ\,10'=92^\circ\,12'\,53''.$

The above examples, with the exception of Example 1, are worked direct from the Tables of Logarithms. As already mentioned, the method of finding the logarithm corresponding to a given number or trigonometrical ratio, or the number or angle corresponding to a given logarithm, is explained in the book of logarithms.

49. Text Books. For the student who wishes to go further into Mathematics the following textbooks can be recommended.

Algebra.—"A Treatise on Algebra," by Charles Smith (7s. 6d. Macmillan & Co.); "Higher Algebra," by Hall and Knight. (7s. 6d Macmillan & Co.)

Geometry. "A School Geometry." Hall and Stevens. (4s. 6d. Macmillan & Co.)

Trigonometry.—"Plane Trigonometry." Todhunter and Hogg. (5s. Macmillan & Co.)

Conic Sections.—"Geometrical Conics," 6s., and "Conic Sections," 7s. 6d., both by Charles Smith. (Macmillan & Co.)

"Differential Calculus for Beginners." Joseph Edwards. (4s. 6d. Macmillan & Co.)

"Integral Calculus for Beginners." Joseph Edwards. (4s. 6d. Macmillan & Co.)

Trigonometry *concluded*

CABLE-MAKING AND LAYING

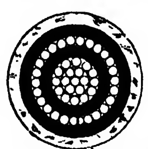
Concentric and Three-core Cables. Methods of Joining Cables. Systems of Cable Laying

Group 10
ELECTRIC CABLES
2

Continued from page 6548

A CONCENTRIC cable [4] consists of a prime central conductor, an insulation covering, a second conductor outside the insulation, a second insulation on top of the second conductor, and a protective covering. The second conductor is in the form of a copper wire ring, which is concentric with the prime conductor. The insulation in this make of cable is usually of paper or jute. The reason for this is that the second conductor could not be well applied on a soft indiarubber insulation before vulcanisation, because it might cut through the plastic substance and cause a fault. Further, if the first insulation were vulcanised before the second conductor were added, the second insulation would have to be vulcanised, and while this was being done the first insulation would be vulcanised again. This would destroy all the good properties of the first covering, and cause it to crack when bent.

Making Concentric Cables. In the making of concentric cables, the first process is the making of the central stranded conductor by means of the stranding machine, as already mentioned. The conductor is taken from the stranding machine to the paper-lapping machine, where it receives a covering of several layers of strong manilla paper tape. This is applied by being spirally wrapped round the conductor much as though the tapes were wires being stranded round the core.




4. CONCENTRIC CABLE—LEAD COVERED

Each layer of paper is wrapped on in reverse spiral, for the reason stated, with rubber strips. The paper-covered core is now placed in a hot-air chamber, heated to about 250°, to drive out all moisture. Since the paper will again absorb moisture from the atmosphere if left about, it is at once taken to the tanks containing a special hot resinous compound. The paper is thoroughly impregnated with this compound until it is practically waterproof. At the same time, the compound adds a little to the better insulation of the cable. From the tanks the cable is again taken to the stranding machine, where it receives its second conductor. This requires careful application, since, when it is on, the wires forming it must have a combined sectional area equal to that of the prime conductor, because both will have to carry the same amount of current with the same amount of resistance. If the sectional area differed, the smaller conductor would offer more resistance than the greater to the passage of the same amount of electricity. This would cause waste of current and more heat in the circuit, therefore both conductors should be of the same sectional area. The second insulation is now applied by the wrapping, drying, and impregnating processes as before.

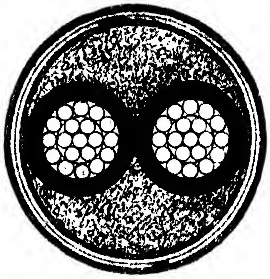
Lead Covering. With a moisture-absorbing material like paper a waterproof covering is necessary; therefore, as the cable comes out of the compound tanks for the second time it is taken to the hydraulic lead press to be encased with a lead sheathing. The method of applying this has been much discussed among cable-makers, some preferring to put on the lead at a high temperature with low pressure, and others at a lower temperature with high pressure.

In the former method, the lead is very liable to small air holes, or pores, and the thickness of the sheathing is not usually the same all the way round. In the second method, owing to the increased pressure, porosity is less likely to occur, and the thickness of the covering is more smoothly and evenly maintained; hence the high pressure process is now becoming general. At the hydraulic press the cable passes through the centre of a die, through which the lead is forced at the same time under very great pressure and at a temperature well below melting point. This gives the cable a closely-fitting protective sheathing against dampness and mechanical injury. With the lead covering on, the cable is ready for testing. In connection with these paper-insulated cables, the great difficulty is to prevent dampness getting to the insulation, because dampness not only conducts electricity, but also quickly rots the paper and causes a fault. When a fault occurs, there is no telling what may happen, so that it behoves makers to see that the cable is sound before it leaves the works.

Testing Lead-covered Cables. The testing of lead-covered cables is rather difficult to conduct in a satisfactory manner. The cable is first placed in water-tanks, and left there for about twenty-four hours, the ends being carefully kept out of the water, because they are not fully protected against dampness. When the test for insulation resistance is made, the ends are carefully prepared to prevent surface leakage by being coated over with an insulating compound. Both the waterproof and the insulation resistance tests are very similar to those for indiarubber insulated cables. It will be noticed that the concentric cable is not tested as soon as the insulation is applied, as the single cable was, and the reason for this will be readily understood when it is remembered that the chief idea right through the process of making the cable is to prevent dampness in the paper.

The unsatisfactory part of the testing when the lead covering is on is this: owing to the method of application, there is always the possibility of weak places occurring in the lead. These will withstand the tests when the cable is newly made and before it has been wound many times on a drum, but very soon after it comes to be wound and unwound in the process of laying, the weak places break down, and when next the electricity is sent through there is a fault shown. After the testing the cable is ready for use. Since lead soon decomposes when laid in the ground, this class of cable is usually laid in conduits. The concentric cable, having two conductors, may be used alone.

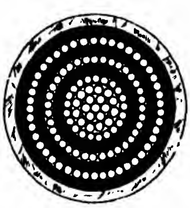
Twin Cable. This is called a twin cable [5] because it has two similar insulated conductors bound together under one protective covering. The two conductors are stranded separately at the machine, and each is separately insulated by indiarubber, bitumen, or paper.

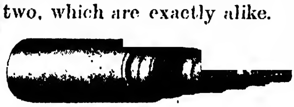


5. TWIN CABLE—DOUBLE-STEEL TAPE ARMOURED

As the conductors are usually small in twin cables, they can generally receive their insulation, if of indiarubber, at the longitudinal machine. If bitumen or paper is used, the insulation is applied by the wrapping process. After receiving the insulation of indiarubber, the cables are tested in a manner similar to the single indiarubber cable. Up to the testing process the two conductors are treated as separate cables, but from this point they become as one. If they withstand the tests satisfactorily, they are placed side by side and closely packed round with broken jute, usually impregnated with resinous or tarry compounds. A stout jute braid is then applied round the packing to keep it tightly in its place, and to make a solid core around which a lead covering or wire armouring may be placed. Before the armouring is applied, the braided cable is passed through the serving tanks to receive its covering of compound, which acts as a preventive against dampness. The lead covering is also put on for this purpose, but it further acts as a mechanical protection.

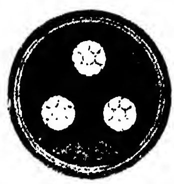
Triple Concentric Cable. This [6] is so called on account of the three concentric conductors which are enclosed within its armouring. It consists of a central conductor, a first layer of insulation, a second conductor in the form of a ring, a second layer of insulation outside the ring, then a third conductor, again in the form of a ring of copper wire, and a third insulation. As the insulation is usually of paper, for the reasons stated for the concentric cable, the usual protective covering is the waterproof lead sheath applied by pressure. The stranding of the conductors, the wrapping of the insulation, and the pressing on of the lead are all done in the manner as described for the concentric cable. If the triple concentric cable is to be used for a three-wire system, the outer conductor is usually made only one-half the sectional area of either of the other two, which are exactly alike.

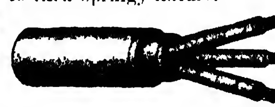




6. TRIPLE CONCENTRIC CABLE—LEAD COVERED

Three-core Cables. This cable [7], as the name implies, has three cores or conductors, each of which is separately stranded and insulated. All three are then bound together within one armouring. A sample of the three core cable before the writer is insulated with bitumen. To prepare this substance for insulation purposes, it must go through a thorough refining process. Much difficulty was at one time experienced in getting this material into such a condition that it was neither so brittle as to crack when bent nor so soft as to allow the heavy conductor to become decentralised when insulated with it. After the refining process the bitumen is compounded with chemicals, one of which is sulphur, and rolled into thin sheets. These are cut into narrow strips, which are wrapped spirally round the conductor, after a lapping of paper or indiarubber-covered cotton tape has been applied on the copper to prevent the sulphur in the bitumen from tarnishing it. The process of vulcanisation is the same as for indiarubber, and it is done for the purpose of adding strength and flexibility to the compound. Each conductor is generally of the same size, and insulated with the same thickness of material. When the insulation is vulcanised, the three cores are placed together and tightly packed round with jute soaked in oily or bituminous compound. A strong braid surrounds the packing, and on the outside of this the armouring is placed. This may take the form of galvanised iron wires, steel tapes, or lead sheathing. If steel tapes are used, they are applied by the steel taping machine and laid on in two spiral layers. The second layer is wound over the joints of the first, so that there is no joint showing right through the steel covering. Steel tapes are an excellent form of mechanical protection, as they are flexible and will withstand a lot of rough treatment without injuring anything underneath them. A covering of strong braid is usually placed over the steel tapes to protect them from rust, and to help to keep down the strain due to their springy nature.





7. SEVEN-STRAND THREE-CORE ARMOURED CABLE

Joining Cables. In the above descriptions only single lengths of cable have been dealt with. When a long cable is required, several of these lengths have to be joined together. The joining operation is very difficult, and much care must be taken in order to make a sound job. In the making of a joint the considerations to be borne in mind are that the joint should offer a resistance as near as possible to that of any other part of the conductor, the insulation about the joint should be as sound as any other portion of the cable, and the joint should be strong enough to withstand a certain amount of rough usage which it is sure to receive when being laid. The method of making the joint varies somewhat with the style of cable being joined. A common way of fastening together two lengths of small size cable (say, nineteen strand) is by what is known as the *married joint* [8]. To make this the conductors are stripped of their insulation for a short distance from the ends about to be joined. The bare conductors are then bound round with a few turns of thin copper binding wire at the place where the insulation ends. This is to keep the strands in place while the outer wires are bent back so as to disclose the central strands of seven wires. These are soldered up solid for some distance and then filed into a long bevel so that when placed together there will be a fairly large surface of each in contact with the other. The two ends are then held together while they are tightly bound with binding wire. The joint is then

soldered over and filed down smooth. The wires should be thoroughly cleaned before joining so that the solder will run well on them. The outer wires. which have been bent back, are now cut off at suitable lengths, alternate ones of each conductor being cut long and short. These are then butted together so that a long wire from one side butts against a short one of the other, and molten solder is poured over the joints, after binding wire has been wrapped over them. Figure 8 shows this joint.

The solder is filed down to smoothness so that there will be no sharp projections which might pierce the insulation. The reason for cutting off the outer wires in alternate long and short lengths is to avoid the overlapping of the wires and to make the finished joint as nearly as possible the same thickness as any other portion of the conductor. If the conductor is a very small one (say, of only seven wires), it is usually joined by one joint in a similar manner to the central strand as described above.

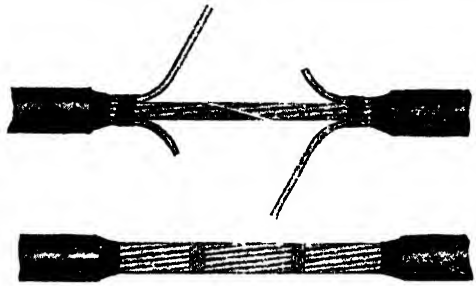
The Telescopic Joint. Another simple way of joining small cables is by the tel[illegible]pe joint as shown in 9. To make this th[illegible]conductors are stripped of their insulation for a short distance and then bound with wire as before. The outer wires of one conductor are then cut off at the binding, and the inner strand of the other is cut off at its binding. The outside wires, B, now remaining are laid up in position again so that they form a hollow cylinder into which the projecting central strand, A, of the first conductor, after being soldered up solid, is inserted. The end of the hollow cylinder touches the binding at which the outer wires were cut off. The whole joint is tightly bound with wire, and then soldered over and filed down smooth, after which it is ready for insulating.

In the concentric cable the inner conductor is joined by the single or married joint, according to size, and then insulated, the outer wires, or the second conductor, having been turned back out of the way. A sleeve of clean copper is usually placed over the joint on the outside of the first insulation, and on the top of this sleeve the second conductor is married, bound, and soldered as mentioned before. In joining concentric cables great care must be used so that the first insulation shall not be damaged in any way during the process of joining the second conductor. The second insulation is applied and then the protective covering.

Joint Boxes. Large cables are usually joined in specially made joint boxes filled up solid with compound to make them watertight and to improve the insulation.

When joint boxes are not used the insulation of the joints in cables is a very difficult matter, as will be readily understood when it is stated that these are the places in which the conductor will offer most resistance and consequently generate most heat. Further, the insulation will have to be tightly and soundly applied without any of its properties being impaired in any way. There are two ways of re-insulating the joints in indiarubber-covered cables; one by means of pure indiarubber, and the other by vulcanising indiarubber. The pure indiarubber joint is made by stripping back the tapes and braids so that they will be clear of the part to be reinsulated. When the indiarubber is thick enough the surface which has been exposed during the making of the copper joint should be trimmed down to the conductor in a long bevel.

This will expose a new, clean surface, to which the pure indiarubber strip about to be applied will stick better. If the copper joint is clean and smooth, the pure indiarubber strip is wrapped tightly and evenly round it, and over the bevelled surfaces, until a thickness equal to, or slightly greater than, that of the old covering is obtained. Strong tapes are then soaked in compound and tightly wrapped over the strip, and for a short distance over the original braiding. The whole joint is then

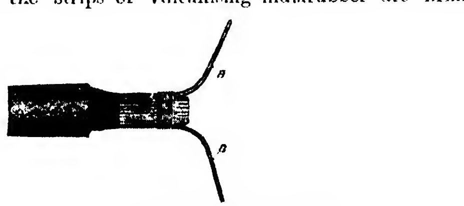


8. MARRIED JOINT

painted over with resinous, water-resisting compound. When the indiarubber insulation is not thick enough to be bevelled down, the new rubber may be lapped for about an inch or so over the old, which ought first to be well scraped and cleaned to remove all grease and dirt. This kind of reinsulation of joints answers all practical purposes in indoor low-pressure circuits where little moisture penetrates and little heat is generated.

Joining Cables Out of Doors. The making of a vulcanised indiarubber joint out of doors requires special apparatus, since it is practically impossible to carry about with one a steam generating plant and vulcanising pans. The molten sulphur bath is probably the most satisfactory portable vulcaniser for outside work. The bath may consist of a strong, cylindrical box, made in halves, and flanged so that they may be bolted together to enclose the joint. The upper half contains a hole through which the molten sulphur is poured, and through which a thermometer is placed so that the temperature of the sulphur can be read. The bottom half contains a tap, through which the sulphur is run out after the process is over. When the box is screwed up with the joint inside, the openings through which the cable passes are packed with common rubber to protect the insulation from the heated flanges.

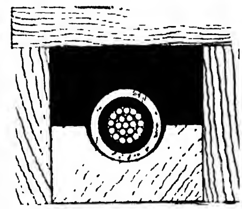
The preparation of the joint for the insulation is similar to that described above. When the bevelled edges have been cleaned, a lapping of pure indiarubber strip is tightly applied so that it just overlaps the thin edge of the bevel. On the top of this the strips of vulcanising indiarubber are firmly



9. TELESCOPE JOINT

wrapped until t[illegible] insulation about the joint is the same diameter as any other portion of the cable. The tightness and evenness of wrapping are essential to prevent small air spaces being left between the layers of insulation. A spiral wrapping of indiarubber-covered tape is placed over the vulcanising

rubber, and in order to keep the insulation in shape, and under pressure, a piece of sheeting is tightly rolled over the tape so as to form a longitudinal seam. On this a spiral wrapping of strong unprepared tape is applied. The sheeting and unprepared tape merely act as a mould while the joint is being vulcanised. As soon as the process is over both are removed. The sulphur is melted over the fire used for heating the soldering irons, and is poured through the top hole in the box. The temperature is maintained by placing spirit lamps under the box. It is advisable to heat the box first so that the temperature of the sulphur will not be greatly diminished when it comes into contact with the metal. After the sulphur has been kept at the proper temperature for the requisite time, it is run out, the box is unbolted, and the joint allowed to cool. The operation is over. A rough test for the degree of vulcanisation may be made by pressing the indiarubber, when cool, with the thumbnail. If this leaves no mark, the rubber may be considered to be correctly cured. If a mark is left the indiarubber is probably under-vulcanised, and if the substance feels hard and solid so that the nail makes no impression, over-vulcanisation has probably occurred. The vulcanised joint is protected by strong tapes and braid, which overlap for a short distance the original braid on the cable. Joints in bitumen-insulated cables are made in a similar manner to those described above, but the paper cables are more commonly joined in special joint boxes, which are watertight and take the place of lead covering.



10. SOLID SYSTEM OF CABLE LAYING

Testing Joints. When the joints are completed, they should be tested to see that their insulation resistance is not much different from that of an equal length of continuous cable. There are several ways of testing joints, but a simple and effective one is known as the accumulation method. The joint to be tested is placed in water contained in a trough which is thoroughly insulated by being raised from the ground on blocks of insulating material.

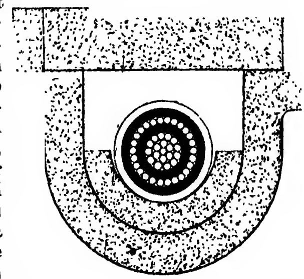
The trough should be tested before proceeding with any other tests. The length of cable containing the joint is connected to one pole of a battery, the other pole of which is connected, through a condenser, to the water by a wire, which is not allowed to touch the cable. The current passing through the insulation of the joint escapes through the water and along the wire to the condenser. This is then disconnected from the trough and connected to a galvanometer, through which the condensed or accumulated current passes, and gives a deflection. The joined length of cable is removed and a continuous piece substituted; the condenser is again connected with the trough and again collects the current passing through the resistance of the cable under test. The battery is kept on for the same time both cases. The second accumulated current sent through the galvanometer as before, and if the deflection obtained in the second case varies but slightly from that of the first, the joint may be considered satisfactory.

The trough may be tested by passing a currens through an electrometer until a steady deflection it obtained. The battery is removed and the electrometer connected to the trough. A decrease in the deflection of the instrument takes place, but if this decrease is only very slight, the trough is sufficiently well insulated for testing purposes.

Cable Laying. When the joints are tested and found sound the finished cable is ready for laying. The question of whether the cable should be laid underground or overhead is soon decided. In England the only method allowed in any of the large towns is the underground system, although under certain circumstances, especially for the transmission of electricity over long distances, the overhead lines may have decided advantages. Overhead wires are chiefly confined to outlying mining districts. There are many in South Wales. The several ways of laying cables underground may be grouped into two classes: (1) the "built-in," or "solid" system and (2) the "drawn-in" system. Figure **10** shows a lead-covered cable laid on the solid system, and **11** shows a cable laid in a conduit in the "drawn-in" system.

Access to built-in cables, when once they are laid, can be made only by opening up the ground, whereas in the drawn-in system, the cables, lying as they do in conduits, may be easily withdrawn into the nearest surface box for inspection. Greater mechanical protection is required in the "solid" method than in the "drawn-in." This is because the cables in the solid system are sometimes laid in the ground direct [12]. The armouring may consist of steel tapes, or iron wires, or the cables may be laid in troughs of wood or iron, filled up solid with compound. Sometimes broad tiles are placed just above the cables to give warning to workmen when opening the ground that the cable is at hand. Precautions are then taken that the pick or spade is not sent through the cable's insulation. In these troughs a good plan is to lay the cables on small bridges of wood, as shown in **10**, before filling up with the compound or asphalt.

Whichever of these plans is adopted, the cables must be laid while the ground is open, and this is a great inconvenience to traffic if the laying happens to be in a very busy thoroughfare. Further, the road authorities allow only a certain length of trench to be open at one time, and this is often a hindrance to rapid laying. When a length of trench is prepared, the drum containing the cable is mounted on a trolley and wheeled along the side of the trench so that it pays off the cable, which is laid in place in the trough. Hot compound is then poured over it. The trench is filled up, and the surface repaved.

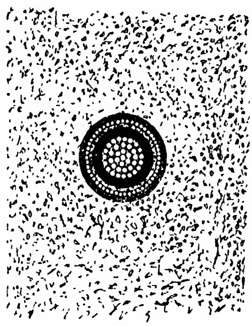


11. CONCENTRIC CABLE LAID IN STONEWARE CONDUIT

Drawn-in System of Laying. In the "drawn-in" system it is not necessary to go to the expense of strongly armouring the cables because they are provided with mechanical protection by the conduits into which they are drawn. The pipes or conduits are placed in the ground before the cables are drawn into them, and when once they are in position the ground need not again be opened. For the purpose of drawing the hauling line through the conduits, a wire is threaded through each section

of them, as they are laid, and it is fastened in the surface boxes. When the conduits are laid, the drum containing the cable is conveniently placed on an axle near the mouth of a surface box, and the end of the cable is connected, by a smooth, strong, fastening, to the hauling line, which is then drawn through the conduits by the wire left for that purpose. The rope is then used for drawing in the cable. The length of cable which may be drawn in at one hauling depends partly upon the weight of the cable but chiefly upon the straightness of the condu'ts about to be entered. In town work the lengths are usually short on account of the numerous sharp bends encountered. When a bend is reached, a length of cable, sufficient to reach to the next surface box, is drawn through and laid on the ground in long loops. The hauling rope is drawn on as before, and then the loops of cable gradually disappear into the conduits. The reason for raising the length of cable to the surface at the bend is to avoid the friction and extreme tension which would arise from the cable being drawn round a sharp corner. Even in straight lengths of conduit the friction is very great, and to reduce this as far as possible a coating of whiting is often applied, as a lubricant, to the cable. Sometimes a chain is drawn through the pipes to clear away any obstacles which might increase the friction or tension on the cable that follows. If the conduits are smooth to begin with, and these precautions are taken against friction, the possibility of damage to the cable during the drawing-in is reduced to a minimum.

Conduits. The cost of conduits [illegible] large-sized cables are laid, a separate way is usually provided for each one, although smaller sizes may be drawn in in pairs. This question of cost has led many people to turn their attention to the manufacture of cheaper kinds of pipes which can be readily joined together. Brick culverts are rarely used now because they take up much space underground, they occupy a long time in building, and are very costly. Earthenware conduits, with two or three cable-ways, can be laid much more quickly and cheaply, and they are now manufactured in a special way so that the joints can be easily made. The disadvantage of earthenware pipes is that they are very liable to fracture, and on account of this other kinds are sometimes substituted.



12. WIRE-ARMOURED CABLE LAID DIRECT IN THE GROUND

Bituminous concrete conduits are often used because they are fairly cheap. They are made in blocks with two or more passages, and are joined together by inserting short mandrels in each passage of two blocks while hot bituminous compound is poured into the joint and allowed to cool. When the mandrels are withdrawn the compound has formed a joint between the two blocks, and the mandrils have kept clear the passages through which the cables will be drawn. Cast-iron pipes are extensively used in connection with Post Office cables, as they have been found to be the most satisfactory.

Considerations in Laying. In deciding at any place whether the cables shall be laid by the "solid" or "drawn-in" systems, considerations are given chiefly to the cost of the cables and conduits. If the "built-in" cables are laid in iron troughs filled up solid with compound and the "drawn-in" system has cast-iron pipes for conduits, then the cheaper method is probably the latter, as in this the cables are not usually so strongly armoured as in the former. After the cost the convenience of access in the "drawn-in" system strongly recommends this method, although it has several disadvantages. The conduits are always liable to infiltrations of water and gases, and if the insulation is not perfectly waterproof, a fault may easily occur. Further, wherever gas collects there is always the possibility of an explosion. The conduits are usually connected with the drain pipes so that the water may run out almost as quickly as it enters. In the solid system there are no spaces in which gas may collect, and the insulation is usually waterproof, therefore the small amount of water which may penetrate the compound around it may be ignored.

Uses of Different Insulations. The different kinds of insulations mentioned have their respective advantages and disadvantages for special classes of work. For a material to be a good insulator it should be moisture-resisting, because moisture is a conductor, and lowers the effectiveness of the insulation: it must be strong and tough, so that it can withstand the rough usage it receives in laying without splitting or tearing, and it should be flexible so that it can be easily wound on drums or bent round sharp corners underground. Further, it is desirable that it should withstand a fairly high temperature without being injured permanently, as heat is generated by the passage of the current along the conductor, and it should be practically unaffected by the acids and gases it is likely to meet when laid in the earth. In high-pressure circuits the insulation must be a very homogeneous mass, because it has to offer great resistance to disruptive discharge. When an installation is found with all or most of these properties, the best cable is that in which the cost, bulk, and weight are least. Good quality of indiarubber, properly applied, possesses almost all these qualities; therefore, from a purely technical point of view it is undoubtedly the best insulator known. Its one great disadvantage is that it is expensive.

Bitumen compound is a fairly good insulator for low-pressure work, but as it cannot withstand much heat without softening, it is unsuitable for heavy current work, where a large amount of heat is generated. Its resistance, thickness for thickness, is not quite so good as indiarubber, but it has the advantage of being cheap. Gutta-percha has a comparatively low melting point, and is therefore confined chiefly to insulation of submarine cables, and underground telephone and telegraph wires, which work only at low pressure. The advantages of gutta-percha for these insulations are that it is thoroughly waterproof and lasting. Paper insulations are suitable for either high or low pressure circuits as they will withstand a fair amount of heat without serious injury. Their disadvantages are that the paper readily absorbs moisture and therefore always requires a lead or other variety of waterproof covering, which adds to the expense. The paper itself is inexpensive.

Electric Cables *concluded*

SHIRT AND COLLAR MAKING

The Making and Dressing of all Kinds and Makes of Shirts. Drafting, Cutting and Finishing. Collar Making. Popular Styles

By W. D. F. VINCENT

FORTY or fifty years ago shirtmaking was one of the cottage industries of England. The general practice then was for the large firms who supplied the shopkeepers engaged in the drapery and outfitting trades to send round to the women of the villages and small towns of the country districts the cut-out parts in a range of sizes, paying at the rate of so much per dozen for the ordinary work of making up. Specially good needlewomen, who could work neat buttonholes and do the other parts of the work exceptionally well, found this a good means of adding to the domestic income.

The general adoption of the sewing machine, and its introduction to the factory system of working, brought about a change in this class of work. It ceased to be a home industry in the sense of home-workers being employed to supply the wholesale merchant with his requirements. Big shirt factories were established in several districts, Devonshire and Belfast being the leading centres, the latter doubtless by reason of its being the seat of the Irish linen trade. London also has become an important centre for the manufacture of linen shirts and what may be called kindred articles, such as collars, cuffs, and the now almost abandoned shirt-front or "dickie."

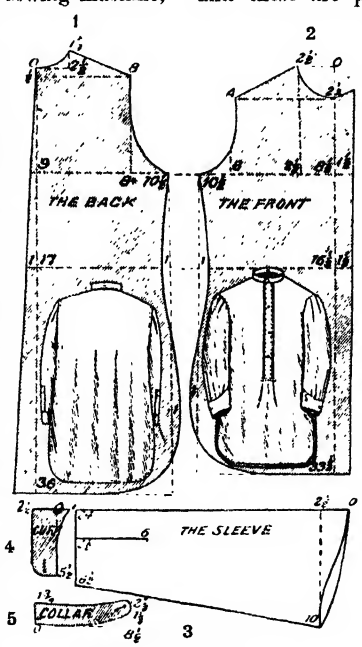
Whether, however, the goods are made at home or in the factory, the principle of production is practically the same.

Cutting Out the Material. In the factory the first thing is to cut out the material in the most economical manner. This is done by laying out a number of folds of the material to be used, and placing the various parts of the pattern, which are usually cut out first of all in tin or stout cardboard, and, after these have been marked round in pencil, cutting them out with a hand knife or band-saw in as many thicknesses as required for the different sizes.

For domestic or individual work, of course, a different plan is adopted, but it is equally important to arrange the pattern so as to use as small a quantity of material as possible.

The various parts of the shirt having been cut, the body part from calico, and front, cuffs and collar from linen, the supplementary parts have next to be attended to, such as the underlining for the cuffs, which is usually a fabric composed of a mixture of linen and cotton, and the backing for the fronts. The quality of a shirt is generally made to depend upon the fineness of the linen employed in making the front and cuffs, which is reckoned according to the number of threads to the inch, as counted through a magnifying glass specially made for the purpose.

The various parts of the different kinds of shirts will be seen by reference to the diagrams, and these are put together by the ordinary methods of sewing, the main object being to fit the body without causing discomfort at any part.



1-5. THE SAC SHIRT

The buttonholes should be very neatly worked, and a sewing machine for working buttonholes is largely used in all shirt and collar factories. This machine, by means of a kind of cross-stitching, does the sewing before the hole is cut, this being done by a chisel, or similar tool, after the shirt or collar has been finished and dressed—that is, starched and ironed.

Great care should be exercised in seeing that the buttonholes harmonise as regards position, that the hole in the back of the collar be exactly in the centre, and that those of the cuffs are properly balanced.

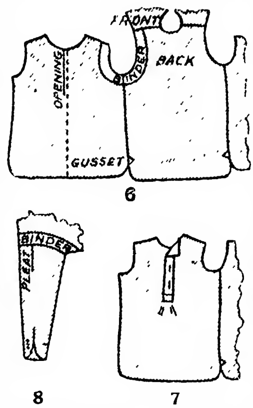
Material for Shirts. The material used for making shirts is a calico, in the trade termed longcloth, varying from 34 in. to 37 in. in width, the price ranging from 5½d. to 10d. per yard—retail—according to quality required.

The quantity of material required for two shirts with stiff fronts and wrists would be 6 yd. longcloth, 1 yd. Irish linen for frontings, and 1½ yd. of heavy interlining. The interlining might be of either linen or cotton.

The wristbands are usually made fourfold—which accounts for the extra length of interlining—to resist the greater wear on them generally. Cottons Nos. 40 to 45, 6-cord, would be suitable for bodymaking; but for fronts, wristbands and buttonholes, 60, 6-cord, would be best. For needles, Singers' ½ would be found suitable.

The material for flannel day shirts varies from 3 yd. to $3\frac{1}{2}$ yd. These are, of course, easier to make, owing to there being no stiff fronts or wristbands to be inserted. The cloth is folded in the same way as for dress shirts, but instead of cutting away a piece for the insertion of the stiff front, a piece of cloth about two inches wide is stitched down the centre, so as to form a broad plait when buttoned over. Then slope out the neck according to the size required. The neckbands of these shirts are generally made of drab or grey sateen.

The wristbands are cut so as to fit just round the wrist about $2\frac{1}{2}$ in. or 3 in. deep. Pearl buttons are used for fronts and wristbands. Owing to the greater strength required of these shirts for day work generally, the same should be made up with 6-cord cotton, 45 to 50.

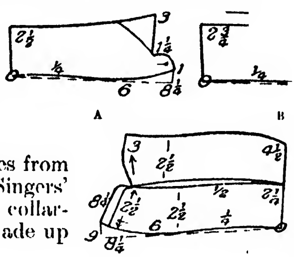


6–8. FITTING THE SHIRT TOGETHER

Linen Collars. The quantity of material required varies according to the shape of collar. The cloth used for fronting is generally Irish linen, which dresses up so much better than cotton, and imparts a higher finish to the collar when dressed, and wears longer.

The collar can be lined with either a heavy cotton or linen interlining; but the latter would be more durable, and would be found cheaper in the end.

The material for collars varies from 34 in. to 36 in. in width. Singers' 0 needles are suitable for collar-making. Collars should be made up in 6-cord, 60 to 80, cotton.



9. COLLAR DRAFTING
A. The "Wing." B. The "Stand." C. The "Double."

Diagram **9** gives reduced models of some of the most popular styles of collars, which only need to be reproduced by the ordinary inchtape to give a good model.

The variations in size can be easily made by adding to or taking from the back.

"Dressing." A new shirt should first be placed in cold water for the purpose of taking out the dress or priming of the cloth of which it is made, and afterwards taken out and washed as household linen, being thoroughly well dried in the open air before starching. While the shirt is drying lump-borax should be dissolved in the proportion of 4 oz. to 6 oz. in one pint of boiling water to half a dozen shirts. The starch (which should always be good rice starch) should then be prepared. Take 1 lb. of starch, add a little blue, which gives the shirt a whiter appearance when dressed, mix the starch in a little cold water, then add water in which the borax has been dissolved, which, however, should first be allowed to cool. The shirt being thoroughly dry, first take hold of the wristbands, and well soak and rub in the starch that has been prepared, and then deal with the front in the same way. The wristbands should next be rolled to front tightly, and the shirt allowed to remain three or four hours if possible; it could be ironed immediately if required, but in this case it would need to be first rolled in a dry cloth, or rubbed down with a dry cloth to take off the surface starch and superfluous moisture. If the starch appears a little thick when rubbing, add a little water to reduce it.

Ironing. First set, or lay out flat, the yoke of the shirt, then neck band, and afterwards the body, seam to seam.

Iron the body of shirt first, then "set" the cuffs and iron the sleeves. When this is done, prepare the front. Place a board (which should be covered with a piece of ironing flannel) between back and front of shirt, and then set for ironing. Next take an oval iron, or polisher, well heat it, and then take a piece of rag upon which a piece of beeswax has been placed, and rub the iron lightly with this—which will cause the iron to run smoothly over the starched front and wrists—but before using, wipe again with a clean duster, to remove any particle of beeswax that might be sticking to the iron. Then, with the heel of the polisher rub briskly, using the point or nose of the iron around neck band. When ironed, fold, and press with flat iron, well air, and the shirt is ready for use.

For the washing, drying, starching, etc., of collar, the same process is used as for shirts, but the quantity of starch required depends upon the number of articles to be dressed.

White shirts are made up in many varieties of fronts and cuffs. Thus the dress shirt has a front 14 in. or 15 in. deep, and about 11 in. wide, with one stud-hole in the centre about 5 in. or 6 in. down from the collar.

The ordinary, or everyday, shirt has a front ranging from 11 in. to $13\frac{1}{2}$ in. long, and 8 in. to 9 in. wide, with two or three buttonholes up the front.

Short-fronted shirts are also made for those who wear high buttoning vests, and the newest style of these are V-shaped, which gives much more comfort than the old round pattern.

Many shirts are now made up with soft fronts, or in other words without the insertion of any kind of front, and it is to this class that the flannel shirt belongs.

Cuffs are usually placed at the wrists, but many are now made with detachable cuffs. Occasionally, shirts are made up with collars attached, but this is the exception.

The fastening can either be arranged up the the front or the back, but the latter plan is preferred. A slit is made about 12 in. deep, and a facing seamed on and the band arranged accordingly.

Football shirts are made up in all kinds of patterns, according to the club selection. The illustration [19] shows the harlequin design, but this is one of scores, including many varieties of stripes, bands, stars, and other designs. They are usually finished at the neck with a turnover collar, and a patch pocket on the breast.

The night shirt is made longer and fuller than the day shirt, but generally speaking is of the same design [14]. It is finished at the neck with a turnover collar and a breast pocket. Occasionally the bottom of the back is cut ten or twelve inches longer, turned up to form a kind of pocket for the feet.

An excellent book on cutting and making all kinds of shirts is published by the John Williamson Co., Ltd., Gerrard Street, W., from whose pages we have reproduced the following system of cutting the two principal styles.

Taking the Pattern. We first proceed to describe the system, and in order to make it as simple as possible we have selected a style of shirt which is very free of complications, and will describe the cutting of this by divisions of the breast measure system for which the ordinary measures of length and width, the same as for a coat, will suffice.

THE BACK [1]. Draw line O 36 and mark off as follows: O to ½, ½ in. O to 9, one-sixth breast plus 3 in. O to 17 the natural waist length. O to 36 the full length desired plus the seams. O to 2½ one-sixth neck.

From these points square lines across at right angles.

2½ to 1¼ one-twelfth neck, and curve back neck. 1¼ to 8 the width of shoulder, as taken on customer, plus two seams. Square down from 8 to 8*. 9 to 10½ one-fourth breast plus 1½ to 2½ in. Square down from 10½, and hollow on line 17 1 in. and add on 1 in. of spring over the seat.

Mark out from 17 1 in., and draw line from O through 1.

THE FRONT [2]. Draw line O 33½. O to 2½ one-sixth neck. O to 8½ one-sixth breast plus 2½ in. O to 16½ natural waist length less ½ in., or by making the distance from 8½ to 16½ the same as 9–17 of the back. 16½ to 33½ 2 in. less than 17 to 36 of the back. Square lines from O, 2½, 8½, 16½, and 33½. O to 2½ one-sixth of the neck. 2½ to A the same as 1¼ to 8. 8½ to 8 one-fourth breast less 1in. 8½ to 10½ one-fourth breast plus 1½ in. to 2½ in. Hollow waist 1 in. Give 1 in. of spring under the hips. Add on 1½ to 2 in. for button-stand and front pleats.

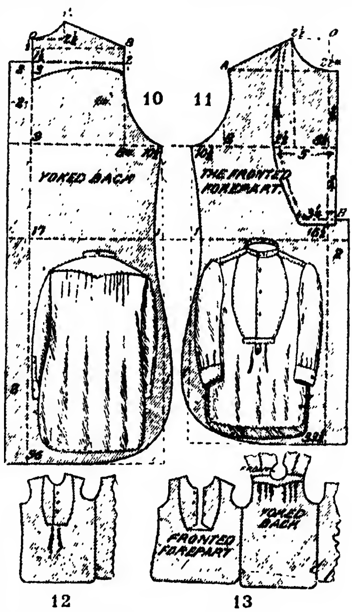
THE SLEEVE AND CUFF [3 and 4]. Draw line O 24. O to 2½, 2½ in. to 3½ in., the smaller quantity for easy-fitting sleeve. O to 24 the length of sleeve less cuff and shoulder-width, due provision being made for seams. 2½ to 10 half scye plus 1 in. to 1½ in. 24 to 6½ one-sixth breast plus ½ in. Cut as in the underpart, about 2 in. or 2½ in. from the crease.

For the cuff [4] draw lines O 2½, O 5½. O to 5½ half size of cuff desired, plus 1 in. O to 2½ depth of cuff desired plus ½ in. Add on point at 1 or shape to taste.

The cuff may be varied considerably, and this is but one style of many.

THE COLLAR [5]. Draw line O 8½. O to 8½ half neck plus 1 in. 8½ to 1½, 1½ in. Draft collar 1¾ deep at back and 1 in. deep at front.

The Finished Article. In the accompanying diagrams we give a few suggestions on making-up. Diagram 6 shows the back joined to the front at the shoulders and the side; about 2 in. from the bottom of the side seam a gusset is put. The opening is cut down the front about ¾ in. to the right of the centre and about 13 in. deep. This is then turned in, and forms the button-stand, whilst the other side is turned in to form a pleat, and the underpart turned over to meet it, the holes being worked in this as shown in 7.



10-13. YOKED AND FRONTED SHIRT

In 8 we show the sleeve made up; the fulness at the top may either be put in the form of pleats or gathers, which also applies to the cuff; the slit of the sleeve should be faced so as to take buttons if necessary. Binders are often put on round the armhole in order to strengthen it at that part. These are shown in 6 and 8.

Yoked and Fronted Shirts. The vast majority of shirts are now made up with yokes and inserted front. This plan is now adopted not only for white and coloured linen shirts, but also for flannels, so that this is by far the most popular style of shirt at the present time. These two features do not necessarily go together; the yoked back may be used with the plain forepart [2], or the fronted forepart may be used with the sac back [1].

THE YOKE BACK [10]. Draw line O 36. O to ½, ½ in. O to 3, 3 in. more or less to taste. O to 9 one-sixth breast plus 3 in. O to 17 natural waist length. O to 36 full length of back plus two seams. Square lines at right angles to these points. O to 2½ one-sixth neck. 2½ to 1¼ one-twelfth neck, and curve back neck. 1¼ to 8 the width of shoulder plus two seams (½ in.). Square down from 8 to 8*. 9 to 10½ one-fourth breast plus 1½ in. to 2½ in. Square down from 10½. Hollow inside this line 1 in. at waist, and add 1 in. of spring over the seat. Shape bottom of yoke to taste. In the diagram it is pointed in the centre, which is 3 in. down

from O. The depth at the scye is 2 in. Let back overlap this at the shallowest part at least ½ in., as shown by dot and dash line.

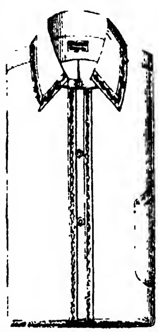
THE FOREPART [11]. Draw line O 33½. O to 2½ * one-sixth neck. O to 8½ one-sixth breast plus 2½ in. 8½ to 16½ the same as the back from 9 to 17. 8½ to 33½ about 2 in. less than 9 to 36 of the back. 8½ to 2½, and O to 2½, each one-sixth of the neck.

Square across from 2½* to A, and make 2½ to A the same width as 1¼ to 8 of the back.

8½ to 8 one-fourth breast less 1 in. 8½ to 10½ one-fourth breast plus 1½ in. to 2½ in. Square down from 10½.

Hollow side seam at waist 1 in., and give about 1 in. of spring over the hips.

THE FRONT. The shape of the front varies considerably, but the more general size is that indicated on this diagram.

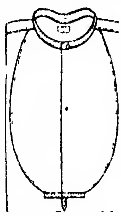


14. NIGHT SHIRT

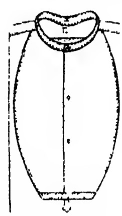
The depth extends to within 1 in. or 1½ in. of waist line, 16½.

The width of the front at the bottom is 3¼ in., including the ¾ in. buttonstand added beyond the centre line.

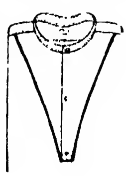
The width across the widest part of the breast just below the depth of scye line is 5 in., including the ¾ in. buttonstand. From this point it is continued up to the shoulder seam, where it is made 1 in. wide.



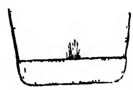
15. DRESS SHIRT



16. MORNING SHIRT



17. FRONTED SHIRT



18. DETACHABLE CUFFS

To provide for seams where the front is joined at the breast, allow ¾ in. at both side and bottom.

From B downwards allow 2 in. for pleat at bottom of the front.

The sleeve, cuff, and collar are as described on 3, 4, and 5, though in the illustration we show a plain round cuff; that, however, is a variation easily introduced.

19. FOOTBALL SHIRT

Important Details. The yoke is intended to be double.

The extra width of the back is either gathered or pleated in to the yoke just above the blades on either side of the point, leaving about 1½ in. plain on either side of the point. This is shown in **13**, as well as the joining of the forepart to the yoke.

In **13** we also illustrate the front sewn to the forepart down the sides, from which it will be seen there is extra width on the forepart below to be gathered or pleated in. This is generally done by a box-pleat, and the bottom of front is either finished with a strap, or the front is left long enough to overlap the necessary amount.

On the figure in **11** we illustrate the strapping method, and in **12** the plain method.

These fronts are either made double, or of more thicknesses.

When working-men's shirts are made up from Oxford shirting in this way, the lining of the front is of unbleached calico.

When flannel shirts are made up in this way, the inner front may either be of the same flannel or a thinner one.

The number of holes put in the fronts is usually three, though for dress shirts this number is sometimes reduced to one.

For white linen or cambric shirts the fronts are made up with four thicknesses, to take the starch, and in this case the cuffs follow suit.

A tab is often put on the bottom of the front to fasten it to the top button of the trousers.

All the seams are turned in and stitched or felled, and are never left raw. This necessitates the provision of rather wider seams than the usual ¼ in., so that they ought not to be less than ⅜ in. or ½ in. The bottom side seams are left open about 3 in. or 4 in. up, and the top of the slit finished with a gusset.

The other diagrams on this page not already referred to [15–18] serve to illustrate the various styles when made up, and are explained in the descriptions given underneath.

Concluded

COMPANY FORMATION

The Company Promoter and His Duties. Articles of Association. Directors. Working a Limited Company

By D. N. DUNLOP

THE fundamental principle underlying all joint-stock enterprise is financial co-operation, which legislation endeavours to place on a sound basis of equity. The very freedom of the system of British Company Law, as set forth in the Act of 1862, constitutes its gravest danger. Abuse of this freedom by unscrupulous promoters and directors led to further measures for the protection of the public in the shape of the amended Companies Act of 1900, without seriously curtailing the freedom. This Act provides that all the information likely to influence would-be investors no less than the absolutely essential facts, should be registered and made public, thus insuring that companies should not be launched without due guarantee of soundness, or without giving the investing public a chance of judging of the merits of the enterprise. The Act secures, in addition, a more intimate control on the part of shareholders, and protects creditors of the company by enforcing a public registry of all mortgages and charges created by the company.

British company law is now, in its amended form, as perfect as criticism and experience can make it, while refraining from exercising a cramping or stifling influence on commercial and industrial enterprise. Against the individual losses and mischief imputed to joint-stock companies in the past must be set the immense benefits which the stimulus of the co-operative principle, combined with limited liability, has conferred upon British trade. Joint-stock companies are divided into three classes:

(A) Companies with unlimited liability;

(B) Companies whose liability is limited by shares;

(C) Companies whose liability is limited by guarantee.

Class A is now practically extinct. B is the normal type and by far the most important.

The Promoter. What are the legal position, the responsibilities, and the risks of the business man who becomes a company promoter? The most frequent cause of disaster to the amateur promoter is ignorance or misapprehension of his fiduciary relation to the company he promotes, as understood in the doctrine of equity. The duties, responsibilities, and obligations of a promoter which constitute his fiduciary relation to the company are various and great. The promoter, or promoters, of a company have in their hands, as Lord Cairns puts it, the creation and moulding of a company. They have the power of defining how, when, and in what shape and under what supervision it shall come into being and begin operations as a trading company. The promoter prepares and settles the memorandum and articles of association of the company, furnishes it with directors and fixes the minimum subscription on which the directors may go to allotment. In one word, his will controls the future destiny of the unborn corporation. It stands to reason that, under these circumstances, equity demands that the promoter should not abuse his trust by taking advantage of his own power and the company's defencelessness to despoil it or involve it in difficulties.

The Stumbling Block. The practical meaning of the warning here conveyed is briefly this. It is assumed, as a matter of course, that a promoter does not undertake to promote a company for nothing. He may have some property he wishes to dispose of to the company when formed, such as a business, a mine, a concession, a patent, etc., or he may be induced to give his services for a consideration in cash or shares. The point at issue is this: he may make any condition he thinks fit, arrange for the disposal of his own property, or of property in which he is interested, on terms advantageous to himself, but he is compelled to make full disclosure of his interest and position in regard to one or other of these profits. The penalty in case of failure thus to disclose his interest is that he is not by law allowed to retain such profit. If he dispose of a business to the company, the accounts must be audited and the value of the undertaking strictly estimated on an equitable basis. If he sells a property such as a mine, *he is bound to disclose the profit he is making by the transaction*, for he stands in the position of trustee to the company he is promoting. The company must enter into a contract with him with its eyes open.

The position of the promoter is, therefore, that the company has in equity the right to all profit or remuneration obtained by the promoter as its trustee unless it has waived that right after being put in full possession of all the facts—that is, of the nature and amount of the interest. The Act further demands [Sec. 10 (1)] that any such moneys and interest shall be specified in the prospectus, so that the company—that is, the shareholders—may duly take this into consideration before investing their money in the concern. It is the duty of the directors to see that this disclosure is duly made in the prospectus, for once they are appointed, the liability is shared by them. A vendor to any company about to be formed should, therefore, avoid any share in the promotion of the company, unless he be prepared to take upon himself the obligations of a promoter and to make full disclosure of his interest.

The Duties of a Promoter. The duties of a promoter, when forming a company, are as follow:

(1) To prepare a draft of the preliminary agreement in case of property or enterprise to be acquired by the company.

(2) To prepare the memorandum and articles of association of the company and to get six other persons of full age to subscribe them (they need not subscribe more than one share each).

(3) To pay duty on the company's capital and the registration fees.

(4) To select and appoint a board of directors to act.

(5) To file their consent to act with the registrar.

(6) To present the memorandum and articles for registration, together with a statutory declaration.

(7) To prepare the prospectus according to statute (Sec. 10 (1)], being careful to include the thirteen particulars of disclosure required by law.

(8) To have the prospectus signed by all mentioned therein as directors.

(9) To file the prospectus with the registrar.

(10) To advertise the prospectus.

The Directors' Preparations for Business. The company is now promoted and the shares have been publicly offered for subscription; as soon as the minimum subscription, specified in the prospectus, or failing this, the whole of the nominal capital, has been subscribed, the directors take the following steps before the company is ready to begin business as a trading company:

(1) Proceed to the allotment of shares.

(2) File a return of the allotment with the registrar.

(3) File a statutory declaration for the commencement of business according to Section 6 of the Act and obtain from the registrar a certificate entitling the company to begin business.

Management of the New Company. Further immediate steps in the management of the newly registered company include the following:

(1) Prepare preliminary report for presentation and discussion at the first statutory meeting of shareholders (Sec. 12), which must be held not more than three months after the date of the certificate authorising the company to begin business.

(2) File this report and obtain a certificate for it from the registrar.

(3) Circulate the report, sending a copy to each shareholder at his address in the register, *seven clear days* before the day appointed for the statutory meeting.

(4) Hold the statutory meeting (Sec. 12).

(5) Register mortgages and charges and endorse on every debenture or debenture stock a copy of the registrar's certificate of registration (Secs. 14 to 18).

(6) Preserve and file copies of instruments of mortgage or charge for inspection at the registered office of the company.

(7) Keep a list of directors at the registered office of the company and send returns to the registrar.

(8) Make out an annual summary and list of members.

The above is the correct statutory order of procedure in the formation of a company. We shall now examine some of the essential points a little more closely.

The Memorandum and Articles of Association. The memorandum of association is the basis or charter of the company's constitution, and as such is a public document registered with the articles of association at Somerset House. Five important points are required by law to be set out in the memorandum, as follows:

(1) The name of the proposed company, with the addition of the word *Limited* as the last word in such name.

(2) The part of the United Kingdom, whether England, Scotland, or Ireland, in which the registered office of the company is to be situated.

(3) The objects for which the proposed company is to be established.

(4) A declaration that the liability of the members is limited.

(5) The amount of capital with which the company propose to be registered, divided into shares of a certain fixed amount.

The Objects Clause. No. 3 is the most important of the clauses. Once the objects are specified, the company is bound down to these and cannot undertake anything beyond these. By the definition of these objects, as stated in the memorandum, the sphere of the company's activities is strictly limited. The State, having incorporated the company for a special purpose, in respect of which shareholders invest their money, will not authorise the money being applied to any other enterprise, held to be ultra vires or in excess of their statutory powers, even by full consent of the shareholders. Hence, certain powers, such as borrowing powers, power to accept bills of exchange and other negotiable instruments, power to sell and dispose of the company's undertaking without a winding-up, or to promote another company, power to pay preliminary expenses and the amount of the minimum subscription on which the directors will proceed to allotment, should all be inserted in the memorandum. In addition, it should be distinctly stated of what kind of shares the capital is to consist, whether there be preference shares, and if so, what privilege and rights they carry, and whether the preferential dividend be cumulative or not.

The memorandum and articles of association must be duly signed by seven persons of full age and not standing under any legal disability. Each signature must be duly witnessed. The memorandum need not necessarily be printed, but the articles are required to be printed; both must be stamped with a 10s. deed stamp and with the fee stamp, and must be registered by the Registrar of Joint Stock Companies at Somerset House.

The Board of Directors. There are several important points in connection with the position of a director in a joint-stock company which should not be lost sight of.

The company, being a legal abstraction of a co-operative aggregate, cannot do anything of itself or act except through agents, known variously as directors, managers, council or board. The law regards them all as directors, if they are the accredited representatives or agents of the company. The directors are chosen by the promoter, who is generally anxious to secure an attractive board, which will form a guarantee and induce the public to subscribe. Great abuses have arisen out of this inducement held out to the public: names of weight have been prematurely advertised as directors, sometimes on the faith of a half promise, sometimes as a decoy which has proved only too successful, the public discovering too late that the very man whose name formed a guarantee of success had refused to act as director.

The new Act of 1900 (Sec. 2) has effectually prevented this abuse by requiring that the consent in writing to act as director must be filed before the articles nominating him as director can be registered or the prospectus issued.

The director is further required to subscribe the memorandum of association for his qualification shares, or to sign and file with the registrar a contract in writing to take from the company and pay for his qualification shares (if any). The first of these courses is to be recommended, as the second presents serious difficulties owing to the fact that a contract cannot be made with a company which has no legal existence; and if it be made with the promoters, the company, not being a party to the

contract, would have no locus standi to enforce it. The director must take his qualification shares *from the company* and within two months of his appointment, or else vacate the office.

If a director be not legally appointed in accordance with these requirements of the Act and yet exercises the functions of a director, he is liable to a penalty of £5 a day.

A director is criminally liable for any fraud, misstatement, false statement, failure to disclose or to comply with the statutory conditions of which he was cognisant, or of which it was his duty to be cognisant, but he is not liable for the frauds of his co-directors, if he be himself deceived by them; or for mere errors of judgment. Directors are, in short, expected to fulfil their duties as agents faithfully, honestly, and diligently. When guilty of a breach of trust, the company has the remedy of bringing an action against the director for misfeasance; if the company is being wound up, a misfeasance summons may be taken out by the official receiver or by a creditor, compelling the director to repay misapplied moneys or to make compensation for loss.

Going to Allotment. In the past, winding-up orders were frequently due to the undue precipitation of the directors in proceeding to allotment before a sufficient subscription had been raised. By Section 4 of the Act of 1900, legislation seeks to obviate this danger, by requiring that allotment shall be made only when the amount fixed by the memorandum or articles of association as the minimum subscription has been subscribed, or, if no amount has been fixed, then the whole amount of the share capital. Both these amounts are to be reckoned exclusively of any amount payable otherwise than in cash. Other sub-sections fix the amount of the shares payable on application at not less than 5 per cent. of the nominal amount of the share. The time limit allowed the company for raising the minimum subscription is 40 days after the issue of the prospectus, on the expiration of which, if the directors may not proceed to allotment, they must forthwith repay all money received from applicants for shares. Repayment *without interest* must take place within 48 days after the issue of the prospectus; after that period, repayment is burdened with interest at 5 per cent.

Although directors may not proceed to allotment before the minimum subscription has been raised, they may give a provisional acceptance of a subscriber's application, subject to the statutory conditions as to allotment, provided they notify him to that effect.

Beginning Business. A point of the utmost importance to persons dealing with a company in the early stages of its existence is the question of contracts. No contracts entered into with a company before the certificate entitling it to begin business has been granted is binding on the company; it is only provisional—that is, contingent on the grant of the certificate. But on the day the certificate is granted, *the contract becomes* binding, says the Act [4 (Sec. 3)]. The contracting party cannot, however, withdraw from his agreement with the company, pending fulfilment of this condition, unless the prospectus contain any false or fraudulent statement material to the contract, in which case he is entitled to rescind his agreement.

Mortgages and Charges to be Registered. There are four classes of mortgages and charges which are required by the Act to be registered [Sec. 14 (1)]:

(*a*) A mortgage or charge for the purpose of securing any issue of debentures (including debenture stock);

(*b*) A mortgage or charge on uncalled capital of the company;

(*c*) A mortgage or charge created or evidenced by an instrument which, if executed by an individual, would require registration as a bill of sale;

(*d*) A floating charge on the undertaking or property of the company.

All these classes of mortgages and charges must be registered by the Registrar of Joint Stock Companies at Somerset House. The points to be entered on the register are:

(1) The date of the creation of the mortgage or charge.

(2) The amount secured thereby.

(3) Brief particulars of the property mortgaged or charged.

(4) The names of the mortgagees or persons entitled to the charge.

In the case of debentures it is sufficient to register ·

(1) The total amount secured by the whole series.

(2) The date of the resolutions creating the series and of the covering deed (if any) by which the security is created or defined.

(3) A general description of the property charged.

(4) The names of the trustees (if any) for the debenture-holders.

These provisions form the investor's safeguard, for, as mentioned above, every debenture stock must be indorsed with a copy of the registrar's certificate of mortgages and charges. But as the Act does not cover any but these four classes of charges, it will be seen that there are risks outside this certificate which must be either inquired into or covered by insurance.

Inspection of Registers. The register at Somerset House is open to inspection by *any person* on payment of a fee not exceeding 1s. The company's own register is, on the other hand, accessible only to members or creditors.

The company is compelled to keep on record a copy of every instrument creating the mortgages and charges which come within the section of the Act, and to allow any member or creditor to inspect the same on payment of a fee not exceeding 1s. It is well to note that the right to inspect also covers the right to copy, and that a shareholder can depute his right to inspect to his solicitor.

Every shareholder has a right to transfer his shares, subject to the regulations of the company, who may require that all transfers receive the approval of the board of directors before registration. This regulation is often included in the memorandum or articles in order to protect the company against insolvent or undesirable shareholders. The directors' right to veto, however, applies only to cases in which the objection is to the transferee and not to the purpose for which the transfer is effected.

Continued

LIFE AFLOAT

Climbing the Ladder of Promotion on Board Ship. The Mercantile Marine. Examinations for Ship Officers. The Routine of the Ship

Continued from page 6665

By J. P. LORD

THERE is one point about the merchant service which is especially attractive to the youth who desires to go to sea—namely, that birth and influence are not necessary to attain command, fitness being the only requisite.

Staff of a Steamship. The staff of a large steam vessel is divided into three main sections, at the head of which stands the captain. First, there is the executive, or deck staff, consisting of the captain himself, and at least two mates, but usually three or more, as officers. Petty officers are the boatswain and his mate, the carpenter, quartermasters, the sailmaker, and gunner. Then comes the crew, divided into A.B.'s, or able seamen, ordinary seamen, and boys. Next comes the purser's staff, consisting of purser, clerks as officers, stewards as petty officers, and assistant stewards, cooks, cabin stewards, and cabin boys, as crew. Lastly, there is the engine-room staff, commanded by the chief engineer, with second, third, and fourth, and possibly more, engineers as his assistants, especially where a refrigerating plant is installed. Greasers, donkeyman, firemen, and trimmers, form the complement of the crew.

The first division is the most important, and as it is the only one in which command can be obtained, or in which the highest posts are open to the penniless youth with no influence of any kind, we shall consider it first.

We shall premise that the would-be sailor is between fourteen and sixteen years of age. He wishes one day to be a captain, and wants to know how to attain his ambition. There are two recognised methods of becoming an officer in the mercantile marine. The first is to work one's way up from the bottom; the second, or more aristocratic method, is by apprenticeship. Working one's way up is known as "coming through the hawse holes"; but, provided that the officer who has attained rank in this fashion is skilful, smart, and gentlemanly, he will not find that stand in his way. Some of our best captains have been "before the mast," as being a common sailor is called. We shall take this method first, detailing the duties of the various members of the crew and petty officers.

Joining a Ship. The youngster who desires to join a ship should apply to the shipping master at any of our large ports from which sailing ships set out, for though a modified qualification can be obtained by joining a steamer, still, that qualification is of little use in later life. A ship having been found for the boy, he will have to sign on the articles in that capacity, appearing at the shipping office for that purpose. His pay will be merely nominal, ranging from 6d. a month to possible 4s. On board, he will have to make himself generally useful, being at the beck and call of everyone in his department. He will learn to go aloft, to splice and make knots, and to clean brass-work. From his elders he will pick up a considerable amount of knowledge, and after he has been a few voyages, or possibly only one, if he is about seventeen, he will be given a discharge as an ordinary seaman. At the end of each voyage, when the crews are paid off at the shipping office, each member receives a discharge paper, stating the length of the voyage, the conduct of the individual, and his capacity. These he must preserve, as he must show them when he seeks another ship.

Ordinary Seaman. As an ordinary seaman, the young sailor will be expected to be capable of taking his part in the working of the ship, but he will not be expected to steer, nor will he generally be entrusted with repairing the more important portions of the rigging. He will have to take his turn at the "look-out" during his watch. Here we may say that the crew of a ship is divided into two watches, the "starboard" and "port," and each is on duty for four hours at a time, beginning at 4 a.m., except during the dog watches, which are only of two hours'duration—namely, from 4 p.m. to 6 p.m., and 6 p.m. to 8 p.m. The object of the dog watches is to ensure a change for the men, those who have two night watches one day having only one the next. The ordinary seaman has to help to stow cargo, under the direction of the mate, unless he is occupied in hauling on the ropes of the derricks, a task at which he is generally employed. If he shows himself smart, he may be allowed to take a hand at the wheel in fair weather, or may be put to assist an A.B. in heavy weather, and thus he learns how to steer. When he can do this, and has shown himself smart aloft, he will get his discharge as A.B., or *able-bodied seaman.*

The "A.B." To get thus far usually takes a youngster four years, and he does not then remain in the forecastle, where the men are berthed. If he is desirous of being an officer, the Board of Trade requires only that an applicant for examination for second mate shall be able to show discharges for four full years at sea on an ocean-going vessel. If, however, he has not put in his full time the A.B. must ship in that capacity, when his pay will be between £2 and £3 a month. As A.B. the sailor is expected to be accomplished in all the ordinary knots and splices, to be able to steer accurately, to heave the log (under supervision), and to know the marking of the hand lead-line, and to be able to give the correct depth of water when using it, to manage a small boat, and to do any work aloft or on deck which may be required of him. The A.B.'s are the seniors in the forecastle, and a certain proportion of them are distributed in each watch.

Petty Officers. The carpenter and sailmaker are artisans who have learnt their trade ashore, as well as having had practical training at sea, when, as A.B.'s, or even ordinary seamen, they have been attached as mates to carpenters and sailmakers. They look after the up-keep of the fabric of the ship, and the repairing and making of the sails. Besides this, the carpenter takes soundings of the wells in the ship at regular intervals, and reports to the officer of the watch how much water there is in the bottom of the vessel, for very few ships are absolutely dry. In times of emergency, he has to be able to perform the ordinary duties of a sailor, and go aloft to make or take in sail.

The boatswain and his mate act as sergeants over the two watches, directing work to be done rather than doing it themselves. However, when an officer

is supervising, they have to take their share of the labour. They are always experienced men, and when really good, are of more real service to the captain than some of his junior officers.

Quartermasters and Gunners. Quartermasters and gunners, when native crews are carried, are usually to be found only on board large steamers. The former are in charge of the wheel, two being attached to each watch, and taking turns at the helm. They act as general messengers for the officer of the watch, see that the lights are properly burning, and that the look-out is on the alert. They strike the bell every half hour, assist in heaving the log, or take readings from the patent log, make signals with flags, and attend to the rockets and fire signals. The gunners are practically only cargo officers. They take charge of the hatches, seeing that the cargo is put in properly, and generally assist the officers on duty. They look after the ship's armoury, and keep all the bright work clean. When there are many boats attached to the steamer, some of them are in charge of the gunners. When the cargo is in the hatches, the gunners have to send to the clerks and purser accurate lists of what is in the hatches to which they have been appointed. They make themselves useful, standing by and passing the word, and so forth, and have their proper stations at boat and fire drill. On boats manned by natives, the gunners are selected for their knowledge of the language and are often themselves half-castes. While speaking of lascar crews, we may mention that the quartermasters, where native, are called *seacunnies ;* the boatswain is the *serang*; his mates, the *burra* and *chota tindals ;* and the carpenter is the *mistri.*

The cook and cook's mate, with the steward, are the only members of the purser's staff carried on sailing ships which do not carry passengers. The steward is usually the captain's private servant, who looks after the stores and their issue. He is rarely a sailor. The cook and cook's mate are both supposed to be sailors, and are liable on board smaller vessels to be called on to go aloft and assist in the working of the ship at any time. The Board of Trade accepts service as a ship's cook as proof of practical sea training, and four years' service as such entitles a man to go up for examination as an officer, though, naturally, this privilege is seldom exercised.

Becoming an Officer. Having put in his time at sea, and got his rating of able seaman, the young man is qualified to go up for his examination as second mate, the first step to responsibility. But to do so, he will require to have studied hard during his spare time at sea. This is essential as far as seamanship is concerned, but for navigation he need not be so particular, for much of the work can be learned ashore in one of the many excellent nautical schools, a short sojourn at one of which is now becoming more necessary. Before dealing, however, with the examinations requisite to enable the youngster to assume the blue and gold of an officer we must describe the more general method of becoming an officer—namely, by apprenticeship. Many of the large firms of shipowners accept apprentices on their sailing ships, receiving premiums which vary from £20 to £150. The apprentices are either berthed aft, close to the captain's cabin, or have a house to themselves on the quarterdeck. They have to do the ordinary work of sailors, under the supervision of the officers and with the assistance of several qualified sailors. To them is generally entrusted the management of the sail on the mizzen mast. They are expected to watch the officers taking sights and calculating the ship's position, and after a time are also permitted to take sights for themselves with a sextant. They take their meals by themselves and not with the men or officers, unless on special occasions the captain extends hospitality to them. In good ships they are very carefully watched, and the difficulty of their work is graduated, so that before their time is up they are usually good practical sailors. Knotting and splicing is taught to them by the A.B.'s or boatswain, and the captain or first mate frequently teaches them the elements of navigation. At the end of their apprenticeship they are entitled to go up for the Board of Trade examination. In some ships the smartest apprentice is often given honorary rank as third officer, and thus he learns how to give orders as well as to obey. To shorten the apprenticeship, those who can afford it can be sent to the Worcester or the Conway, two excellent training ships for the mercantile marine, where, prior to going to sea, the boy is taught a certain amount of navigation and seamanship, and enters his new profession with a fair theoretical and practical knowledge of his calling. Two years on either of these vessels counts as one year at sea for purposes of qualification.

First Examination. Whether the candidate has acquired his knowledge before the mast or has been an apprentice he must now pass the examination for second mate, the lowest qualification recognised by the Board of Trade. The examination is held at various large ports throughout the world, but "tickets," as certificates are called, obtained from London are held in the highest esteem by sailors, though all are equally good from the shipowner's point of view. Tickets are of three classes: *Full* tickets, those permitting the aspirant to command any class of vessel (for these, at least a year of the apprenticeship must have been passed in a square-rigged vessel); *fore and aft* tickets, which permit the holder to hold office in the vessels of the schooner type or in steamers; and *steam* tickets, which grant permission to be an officer only on steamships. The last two are not to be recommended. Every sailor should strive to obtain the full ticket. So many fully qualified men are to be obtained that few shipowners care to employ men with lower tickets, always with the exception of the small coasting trade.

The subjects of the examination, which is fairly exacting, are seamanship, embracing the management of all sails and rigging; the standing and running rigging of ships: the bending, unbending, setting, taking in and furling of sails; the management of a ship under canvas, especially in sudden squalls; the rule of the road at sea, and what course to steer to avoid a collision; the lights carried by ships and steamers of every description, and their fog and sound signals; signals of distress, for pilot, and the penalties for misusing them; marking and use of lead line; sending masts and yards up or down; management of boats in rough weather; dunnaging and stowing cargo. Failure in this part of the examination necessitates going to sea again for six months.

In navigation the second mate must show an efficient knowledge of principles, understand all terms, and be able to find the ship's position by ordinary methods, those of Sumner and latitude by altitude of Polar Star excepted. He must know how to estimate the error of a compass or a sextant, and correct the same as far as possible, or to make tables of the errors for future calculation.

He must know how to enter in the log the "Day's Work," and how to use the same for navigation, and find position by dead reckoning as well as by observation. Parallel sailing and Mercator's sailing must be learnt. Amplitude, tides, azimuths, chronometer, longitude by azimuth and chronometer combined, and the use of true and magnetic charts all find a place in the examination, which, as will be seen, is fairly comprehensive. The simple mathematics is confined to the correct use of logarithms, and a small acquaintance with trigonometry, though not a subject of examination, is almost essential. In addition to this examination the candidate will have to pass the Board of Trade sight test, to ensure that he is not colour blind.

Second Mate's Duties. The newly fledged second mate will now have his choice of entering the service of some steamship company or of remaining in a sailing ship. If he goes in the latter he will probably be rated as second mate, and will have to share the watches with the mate and captain. He will be in charge of the deck at fixed times, and when he goes on duty he will receive from his predecessor the orders which have been given by the captain, and will also see that they are written down in the log before the officer relieved goes off duty. He will have to see the holds properly loaded with cargo. He will have a portion of the rigging under his charge and will have to overhaul it at intervals and report thereon. At stated times he will have to work out the ship's position and generally assist in the navigation of the vessel. For the first time he will be in real authority.

Duties of Third and Fourth Mates. On a steamer, however, the newly-made mate will not have much chance of obtaining a post as second mate right away, except on small tramp vessels. He will probably have to sail for some considerable time as third officer, and even as fourth or fifth. The fourth and lower officers in large vessels are not usually in charge of a watch, but are employed in looking after cargo, baggage, mails, passengers, the fabric of the ship and so forth: they are attached to senior officers and work under their directions. The third officer—for on steamers the word *mate* is forgotten—is, however, in charge of a watch, the captain keeping no watch. The third officer's watch is generally from 8 till 12, morning and evening, during which time he has in all things to behave as if in command of the vessel, save when running into danger, or if there be a sudden change of the weather, when he sends a report to the captain. He must never leave the bridge during his watch. He will also be in charge of a hatch, and, like all hatch officers, will have to see the cargo properly stowed in the holds, subsequently writing up a list of what is in his hold, and its destination, which he will forward to the purser or clerk, together with his gangway book, in which a fair copy of this is entered. Twice a day he will have to take sights and determine the ship's position, sending in his report to the captain. All officers above the third have also to do this. He will relieve the bridge for meals, unless a fourth officer is carried, getting his own meals later. He will have to take the readings of the patent log, or send a quartermaster to do so, at intervals during his watch, and enter the same in the log book. Everything that happens during his watch will also have to be written in the log. In his relations with passengers he must not be too familiar, or he will probably be dismissed when his ship returns, the companies rightly holding that their responsible officers should not form too strong friendships with passengers lest the safety of the ship suffer. At the same time he must, when required, take a part in the festivities of the ship and generally be agreeable and courteous.

Second Mate on Steamers. After serving a time as third, the young officer may be promoted to second officer on his steamer, when he will find that his responsibilities are increased. In large vessels the second officer is usually looked upon as the navigating officer, and the captain relies a good deal upon his subordinate's calculations. Indeed, the early morning sights are very frequently entrusted solely to the second officer, much to that worthy's disgust, for as his watches are those between 12 and 4 it is a little hard on him to have to be on deck shortly after eight again, when he has had only a very short sleep. However, the increased dignity and increased pay compensate him to a great extent. In many mail steamers the second officer is in charge of the mails and is responsible for them. He has to see the bags on board, see them stowed in the mail-room, and keep the key himself. On other vessels he keeps the key of the baggage-room, and superintends the periodical baggage days. Besides this he has his hatch to look after, though custom generally gives him the hatch which is least difficult to work.

First Mate. The next examination which the officer has to take is that for first mate, or simply mate. He has to take the same subjects as the second mate, but is expected to show a further knowledge of seamanship. He must know what to do in the event of his vessel being disabled, and be thoroughly capable of executing temporary repairs of all sorts, and of rigging jury masts. He must know how to shift large spars, and manage heavy weights, even in a sea way. He must understand how to load a ship so as not to strain her, how to ventilate his holds and how to stow explosives. In the event of wreck he must be able to make the best provision for the saving of life. He must be able to dock and undock his vessel and must have a practical acquaintance with the forms to be observed in the event of his having to take a ship into port after an accident. In other words, he must show himself perfectly capable of taking entire charge of the vessel in the event of the death or disablement of the master.

Duties of a Mate. His actual duties at sea depend a good deal on the class of vessel. On sailing ships he is responsible to the captain for the proper maintenance of the spars and rigging, and for the general upkeep of the ship's fabric. On liners and steamships he is in charge of the deck, sees to the painting and repairing of the ship, indents for stores and has them issued under his supervision for keeping the vessel spick and span. He is expected to take charge of a table in the saloon at meals and to make himself agreeable to the passengers. He it is who instructs the crew in boat and fire musters, and with the assistance of the purser apportions the passengers to the various boats. He is the captain's right-hand man, and, as a rule, orders from the commander pass through the *chief officer*, as the first mate is generally called.

Examination for Master. After serving with a chief mate's certificate for twelve months at sea, even though employed only as a second mate, the officer is entitled to present himself for the master's examination. This embraces all the subjects which he had to take for his mate's ticket, but the examination is much harder. If he wishes to graduate in the Honour school, the

candidate can offer himself for the extra master's certificate, which is the most searching examination under the Board of Trade.

As captain, or master of a ship the sailor will have obtained the height of his ambition, but he will have to pay heavily for it in responsibility, for the commander is held to be responsible for everything that takes place on board his vessel unless he can prove clearly that he was in no way implicated. He is absolute king on board his ship and his word is law, but he will find that great tact is required if he is to rule his kingdom without friction, and at the same time with the necessary firmness. Sailors have small respect for a weak captain.

Where the captain has no clerk or purser to assist him he will have to prepare the papers and documents which will be described under the category of the purser's duties. He is also expected to have some acquaintance with marine engines, if he be in charge of a steamer.

In his relations with the owners of the vessel the captain will have to exercise great judgment. If he is too servile he will not be respected, and his life will be a burden to him. On the other hand he must remember that the owners are his employers, and unless he has very good cause to do so he should not thwart their wishes. But, above everything, he must remember that his first duty is to his ship and to the lives and cargo entrusted to him, and the owners must take a second place when the two interests clash.

The Purser's Department. Under the purser in large vessels is an army of stewards, clerks, cooks, and cabin servants, for all of whom he is answerable to the captain. Promotion in this department is not so sure as in the executive staff, influence having a good deal to do with appointments to the higher posts.

The purser himself is always a man of education, and in some of the larger vessels may be a member of one of the universities. He is the representative of the owners on board, and his duties are very varied. First and foremost he is in charge of all the ship's papers and either makes them out himself, or sees that they are properly prepared by his assistant or his clerk. Where there is no purser the captain sees to them.

First comes the *official log*, in which is entered records of all births, deaths, marriages, convictions of crew, punishments, fines, forfeitures, illnesses of crew, character and conduct of each member of it, collisions and accidents to the vessel, change of masters and so forth. The draught of water when the ship proceeds to sea must always be recorded in the official log. Penalty for not obeying these rules varies from £5 to £30, the latter being the punishment for making an entry of an event which occurred on a voyage after the ship has entered port and been moored for more than a day. All entries must be signed by the captain and the chief officer, or some other member of the crew.

Ship Articles. The articles contain a list of every member of the crew and also the conditions of their service and their wages, etc. They are made out at the shipping office, but on the voyage the captain can add to the number, and then must make an entry, and show it to the nearest consul when he gets to port.

The *ship's register* must be on board, but the purser does not generally keep that for it has to be posted up on passenger ships in a place where everyone can see it. Before sailing for foreign ports a *bill of health* must be obtained from the [illegible] port of departure, and this must be endorsed by the consul of the port of destination.

A number of manifests will have to be prepared for the various ports to which the ship is bound. Sometimes these are provided from the shore office, but very frequently the purser and his clerks have to prepare them. They are lists showing the particulars of the vessel herself, and a complete list of all the cargo contained in the holds, with marks, numbers, and consignees and shippers. One manifest, giving the entire contents of the ship is known as the *general manifest*, and from this a series of particular manifests have to be prepared for each port to show what cargo is to be discharged there. Copies of the particular manifest, with at least one of the general manifest, all signed by the captain, have to be delivered to the customs authorities at the various ports. In many ports lists of the ship's effects and stores have to be delivered and these are made out by the purser.

Bills of lading, which are receipts for the goods taken on board, are signed by the captain or the purser. They must correspond with the total of cargo by the officers' gangway books in which the officers in charge of the hatches enter every package that is received.

Passenger Lists. On passenger vessels, one or more passenger lists have to be prepared for each port unless all passengers are entered in the *content*, a document enumerating everything on board the ship, and all crew and passengers. Besides these papers the purser has to see that the following documents are obtained: The return list, or E.N.G., which is a list of all members of the crew who have failed to join and the names of substitutes engaged. The A.A. which is proof that the officers have the proper certificates, and the B.B. which is a sworn declaration that the last crew was properly paid. The *last light bill* gives the date up to which all light dues have been paid. The *cocket card* is a customs clearance, and the *jerking note* is a paper stating that the ship has been searched for unentered goods, and bearing a list of bonded goods on board. The *victualling bill* is a list of stores for use on the voyage, and is endorsed by the customs officials. The *port clearance* authorises the vessel to proceed to sea, and the *quarantine certificate* permits her to enter another port.

Besides preserving these papers, and having copies made by the clerks, or making them himself, the purser has to keep a register of all stores in the vessel, and of the quantities issued daily and consumed as well as of all purchases which he may make for the use of his ship. He checks the steward's wine bills, and sees that passengers accounts are properly made out and delivered weekly. He supervises the daily menus for the two saloons, and satisfies himself that the victuals served out to the crew are in good condition and are at least of the amount per man stipulated for in the articles. He makes out a list of all valuables entrusted to his care, and shows it to the captain for verification. He makes out the wages bill at the end of the voyage and enters thereon any advances that may have been made to officers or men on the journey, and at the close of the voyage he attends at the shipping office with the captain or chief officer and personally sees the crew paid off and signed off the articles. He is also expected to see that every member of the crew receives a proper discharge, and in the event of the captain not attending the shipping office he must take the discharges to that official to be endorsed with the character of each recipient.

Arranging Freights. On the voyage, should additional freight offer at a port where the owners of the vessel have no agent, the purser arranges terms of freight if authorised to do so; if not, the captain does this. All the passengers' amusements are under the control of the purser, who is expected to be a good all-round entertainer and to be a friend to all on board.

This is only a general outline of the purser's duties, for each company of steamship owners has its own traditions, to which the purser must adhere rigidly. In some, for instance, all the chief officer's stores, paints, and so forth, are under the purser's control, and he has to see to them being served out when necessary, while in other companies the purser has nothing to do with deck stores.

The assistant purser and the clerks work under the direction of the purser, and have no accurately defined duties. But when only a clerk is carried that individual has to do all the purser's duties with the exception of those which relate to victualling, those being entrusted to the chief steward.

The Steward's Staff. The steward, whether under a purser or not, keeps a record of all stores under his charge, and of the amounts issued to him or by him. This should be made up each day. He gives the cooks what is required for the daily meals, and sees that the same are properly cooked. He is responsible for the cleanliness of the saloons and cabins, and manages the lower servants. In fact, he is butler and housekeeper in one. To become a steward, the aspirant must enter as a cabin boy or under steward, and learn the household work of the ship, trusting to his own energy to gain him promotion. In most of the large companies it is now requisite for the would-be steward to show his capacity for waiting at table in a sea way before being engaged.

The prospects of stewards vary. In large companies the position of head steward is a very lucrative one, and one of great honour, while on a tramp the steward is only the captain's servant. It is impossible to lay down even an approximate scale of pay in the domestic department, for everything depends on the ship and the company it belongs to. Taken altogether, however, sea-going servants are much better paid than their colleagues ashore, and the life is full of charm.

Ships' cooks are of two classes. On liners they must be thoroughly trained chefs, capable of catering for a first-class restaurant. They have usually served an apprenticeship ashore before going to sea as an assistant cook, and then perfected themselves in the management of the floating kitchen. On tramp steamers and sailing ships the cook is an individual who has taught himself, and the dinners he serves up bear testimony to this species of training. Shipowners of to-day are at last beginning to recognise that a trained cook is less wasteful than the self-taught servant, and a movement is in progress for the bettering of this class of servant. The youth who wishes to sail as a cook will do well to obtain some good lessons ashore before he offers himself for a post, and his chances of promotion and regular work will be greatly increased thereby. Cabin stewards and waiters are really sea-going housemaids and parlourmaids.

The Engineer's Department. In this department the line is rigidly drawn between the officers and the crew, just as happens on deck. In olden days the executive officers of the steamer used to look down on the engineers, but better feeling has now sprung up, and the engineers are held to be engineer officers, and are treated as gentlemen. The training of a marine engineer is discussed on page 6366.

Greasers are the labourers of the engine-room. They act entirely under the orders of the engineer of the watch. They are expected to have had some experience ashore in engine-rooms before they ship as greasers. Their duties are varied. They have to keep the engines properly lubricated, to assist in repairs of every kind, and generally to assist in the hundred and one odd jobs which crop up in the engine-room. They have no future before them.

The firemen spend their watches in the stokehold, feeding the giant furnaces which heat the boilers. They are labourers pure and simple, though some experience is necessary before they are able to get the best value out of the coal they are using. They begin as ordinary stokers, and can eventually rise to be a leading fireman, when they will have subordinate charge of one watch of stokers. Under the foreman stoker, or leading fireman, are several trimmers, whose duty it is to enter the coal bunkers and see that the coal is properly fed down to the coal ports in the stokehold, so that the firemen can get at it to shovel it into the furnaces. When not so employed they are engaged in working the ash hoist, clearing out the waste cinders, and throwing them overboard. The coal-trimmer is the lowest servant on a steamer, and his work is both unpleasant and insanitary, the coal-dust often causing fatal lesions to the lungs.

General Ship's Routine. At regular intervals during a voyage on every vessel the crew are piped to fire stations. The exact position of every member has been apportioned by the chief officer and on the pipe going, each man, save the officer of the watch, the engineer on duty, the quartermaster, and greaser, and the principal stokers, have to run to the places assigned to them. The hoses are fitted, pumps manned, or steam pumps started, and everything made ready for suppressing an outbreak. This is practised until each member can perform his duty without the least hesitation or confusion. Similarly, boat stations are practised until each officer and man knows just where he has to take his place in a boat, and what part he has to play in the general work of saving life in case of need. Muster of all hands takes place on Sunday morning, as a rule, when the captain, chief officer, chief engineer, and purser inspect the ship's crew, and also visit the various portions of the ship to see that all is clean and in good order. On weekdays, in well-regulated vessels, the three heads of departments—chief officer, engineer, and purser—inspect the ship and report all clean and well found.

Concluding this section, we may say that the sea offers an honourable and fascinating calling to healthy men. The prospects, especially in the deck department, are good; the life is full of change and is healthy, and, taken all round, sailors are capital fellows, and make firm and loyal friends. No large fortunes can be made at sea, but the sailor can lay by enough for his old age, and he is always well fed and housed.

TRANSIT *concluded*

GREEK–LATIN & GREEK ROOTS

Being the Conclusion of the Course in Greek, Together with a List of Latin and Greek Root Words and their Derivatives

GREEK

Continued from page 6672

By G. K. Hibbert, M.A.

PROSE COMPOSITION

THE student has now arrived at a point when he should devote considerable time to turning passages of English prose into Greek. While a rough working knowledge of a language can be attained without doing much composition, it is only by means of considerable attention given to composition that an accurate knowledge can be acquired.

The student is earnestly recommended to procure Sidgwick's "First Greek Writer" (3s. 6d.), and when he has worked through this, to proceed to Sidgwick's "Greek Prose Composition" (5s.). Both these books are published by Rivingtons, and can generally be picked up at a second-hand book shop. Each contains an English-Greek vocabulary, but if the student should feel the need of an English-Greek dictionary, there is a good one by Yonge, published at 8s. 6d. by Longmans.

It is, however, advisable to rely more on the Greek-English dictionary than on the English-Greek, for the former shows us the *usage* of the Greek word, and gives us the different shades of meaning. If in turning English into Greek we cannot think of the Greek for a certain English word, we can generally think of some synonym, or recast the whole phrase so as to bring it into a form that we can translate into Greek. For example, instead of "in a state of felicity," we could say "being happy," *εὐτυχὴς ὤν*; instead of "he rejected this overture," we could say "he did not wish to do this," *οὐκ ἤθελε ταῦτα πράττειν*, and so on.

In a preceding part of this course [page 5808] we gave the fable of the frogs asking for a king; let us now render into Greek John Milton's reflections thereon:

The Fable of the Frogs: its Moral

"Nor are you happier in the relating or the moralizing your fable. 'The frogs' (being once a free nation, saith the fable) 'petitioned Jupiter for a king: he tumbled among them a log: they found it insensible; they petitioned then for a king that should be active: he sent them a crane' (a stork, saith the fable), 'which straight fell to pecking them up.' This you apply to the reproof of them who desire change: whereas indeed the true moral shows rather the folly of those who being free seek a king; which for the most part either as a log lies heavy on his subjects, without doing aught worthy of his dignity and the charge to maintain him, or as a stork is ever pecking them up and devouring them."

Before attempting to turn this into Greek we should do well to re-write it in English that is simpler and more adaptable to the Greek idiom, somewhat as follows:

"You appear neither to tell nor to understand the myth aright. For the frogs (having become free, says the story of old) asked Zeus for a king: therefore he threw down a log, which to them indeed seemed something senseless, so that they asked for an active king. Therefore he sent a crane, or which the myth says a stork, and he immediately ate them up. And this you reproach to those desiring change; but rather it wishes to tell the folly of those being free and desiring a king, who for the most part either oppresses his subjects as a log, not doing anything in accordance with his dignity and the expense of his keep, or, as a stork, always seizes them and eats them up."

Greek Version of the Above

τὸν γὰρ μῦθον οὔτε ὀρθῶς λέγειν οὔτε συνίεναι φαίνεσθε. οἱ γὰρ βάτραχοι (λέγει τὸ πρὶν, ἐλεύθεροι γενόμενοι) τὸν Δία βασιλέα ᾐτήσαντο· ξύλον οὖν κατέβαλεν, ὃ αὐτοῖς ἀναίσθητον δή τι ἔδοξεν, ὥστε βασιλέα αἰτεῖσθαι καρτερόν. γέρανον οὖν ἔπεμψεν (ἢ ὃν ὁ μῦθος λέγει πελαργόν), ὁ δὲ εὐθὺς κατήσθιεν αὐτούς. καὶ ταῦτα τοῖς μεταβολῆς ἐπιθυμοῦσιν (dative plural of present participle of *ἐπιθυμέω*, governs genitive) *ὀνειδίζετε. ἀλλὰ μᾶλλον βούλεται μωρίαν λέγειν τὴν τῶν ἐλευθέρων ὄντων* (present participle of *εἰμί*) *καὶ βασιλέως ἐπιθυμούντων, ὅσπερ ἐπὶ τὸ πολὺ ἢ ὡς ξύλον βαρύνει τοὺς ὑπηκόους οὔτι πρὸς τὸ ἀξίωμα καὶ τὴν τῆς τροφῆς δαπάνην ποιῶν, ἢ ὡς πελαργὸς ἀεὶ καταλαμβάνει αὐτοὺς καὶ κατεσθίει.*

NOTE. As an exercise, the above might be translated back again into English after the lapse of a few days from the first reading.

General Concluding Remarks. Greek differs from English, French, German, and most modern tongues, in its greater simplicity of expression. It puts things in a direct and concrete form without artificiality and allusiveness. Thus: 1. Where we think of a man as a person, a complex set of attributes, the Greeks would either think of him as a body, a visible and palpable object, or they would denote him by some obvious part of his body—*e.g.*, head, face, or breast, as *ὦ φίλτατον κάρα*, O dearest head.

2. Where we talk of an abstraction, they talk of a thing. Thus the Greeks constantly use the neuter adjective with the article in place of an abstract noun—*e.g.*, *τὸ καλόν*, honour; *τὸ ὠφέλιμον*, utility. So a complex abstract idea is

expressed as two ideas—*e.g.*, *προαίρεσις καὶ πολίτεια*, political principles; *πρᾶξις καὶ συμμαχία*, negotiations for alliance.

3. The Greeks possessed a great love of moderation and of the due mean, as opposed to anything strained or extravagant (*cf.* their use of *εἰ* instead of *ὅτι* after *θαυμάζω, αἰσχύνομαι, κ.τ.λ.*). They did not borrow from other tongues when a native word would do. In this respect no cultivated tongue is so pure as Greek, which in classical times had only 2½ per cent. of loan words, compared with 14 per cent. in Latin. Greek is also sparing of the use of metaphors; hence expressions like "They cast about," "Night drew on," "He became a laughing stock," "On the field of battle," "Silence reigned," must be translated into Greek without the metaphor—thus: *ἐσκόπουν, νὺξ ἐπῆλθε, γελοῖος ἐγένετο, μαχόμενος, ἐν ἡσυχίᾳ ἦν*.

As to Syntax, we may note that:

1. Greek is the richest of all languages in particles—according to Aristotle the one nicety that no barbarian could master! Every sentence unless beginning a treatise, or because of vividness, is joined to a previous one by a connective particle, while in English the sequence of thought is left to be gathered from the arrangement of the clauses.

2. The Greek verb system is far richer than Latin, and can express many more shades of meaning. It has preserved many forms of the original verb of the parent speech—*e.g.*, the dual, the middle, and the aorist as distinct from the perfect. Very interesting is the Greek use of the aorist. In the indicative mood it does generally denote *past* time, but in all other moods the aorist has no connotation of "past." In these other moods the aorist regards the act as a single occurrence, not considering it as protracted, while the present regards the act as extended in time. Examples: *νοσῆσαι*, to fall sick; *νοσεῖν*, to be sick. *πεῖσαι*, to prevail; *πείθειν*, to urge. *εὐτυχῆσαι*, to get a stroke of luck; *εὐτυχεῖν*, to enjoy continued good luck.

In the indicative, the aorist is constantly used where we should use the pluperfect. In fact, the pluperfect is seldom used in Greek, while the aorist can hardly be used too frequently.

We may here note an idiomatic use of the present tense, an idiom which is found also in French, to denote that the act or practice described extends from the past up to the present time—as: *πάλαι προσδοκῶ*, I have been waiting a long time; *τρία ἤδη ἔτη νοσῶ*, I have been ill these three years.

3. Greek prefers a personal to an impersonal construction. Thus, for "It is right for me to do it," they say *δίκαιός εἰμι ποιεῖν*, I am right to do it; also *δίκαιός ἐστιν ἀπολωλέναι*, It is right that he should be hung; *φανερός εἰμι ποιῶν*, It is plain that I am doing it. So from *μέλει μοι*, it is a care to me, comes *μέλω*, I care for; from *δοκεῖ μοι*, it seems to me, comes *δοκῶ*, I think, *or*, I think it best; from *δεῖ*, it lacks, comes *δέω*, I lack, and so on (*cf.* "I am well" for "it is well with me," and "if you please" for "if it please you").

The Order of Words

In English the order of speech is as a rule the same as the order of thought; only occasionally is it changed to emphasise some particular word (*e.g.*, "He saved others, Himself he cannot save"). In Greek, which is a highly inflexional language, the termination of the word generally shows whether it is subject or object, and so the order is much freer, and depends much more on emphasis than on the order of thought. The emphatic word is put first or last in the sentence. In Latin, as in modern German, the verb is mostly considered the emphatic word, and is put at the end; but this is not so in Greek. The order of words in Greek is far more natural than in Latin, being almost as natural as in English; above everything the Greeks avoided artificiality. In English, when any two words are opposed to other two words, the same order is kept in both clauses, but in Greek the order of the second clause is usually reversed—*e.g.*, *τὰς πρῴρας μὲν ἔξω, εἴσω δὲ τὰς πρύμνας* (Thuc. II, 83). This is called *Chiasmus*.

For the sake of clearness the Attic orators often put the relative clause before that which contains the antecedent; this is done very frequently by Demosthenes—*e.g.*, *περὶ ἃ ἑκάτεροι σπουδάζετε, ταῦτ' ἄμεινον ἑκατέροις ἔχει*, Each of you is superior in the points in which you respectively take most interest; *ἃ δὲ νῦν ἀποκρινάμενοι τὰ δέοντ' ἂν εἴητ' ἐψηφισμένοι, ταῦτ' ἤδη λέξω*, I will tell you now what you should answer so as to arrive at the proper decision.

Greek is *par excellence* the language of *naturalness* and of *clearness*; if we read it, it cannot fail to clarify our thinking; if we write it, it will both simplify and dignify our style.

Key to Translation, page 6672

κώνωψ πρὸς λέοντα ἦλθε καὶ ἔλεγεν· ʼΟὔτε φοβοῦμαί σε, οὔτε ἰσχυρότερός μου εἶ· τίς γάρ σοί ἐστιν ἡ δύναμις; ξύεις τοῖς ὄνυξι καὶ δάκνεις τοῖς ὀδοῦσι; τοῦτο καὶ γυνὴ τῷ ἀνδρὶ μαχομένη ποιεῖ. ἐγὼ δὲ πολύ εἰμί σου ἰσχυρότερος, καὶ εἰ θέλεις, ἔλθωμεν καὶ εἰς πόλεμον.' καὶ ὁ κώνωψ ἔδακνε τὰ τοῦ λέοντος ἄτριχα πρόσωπα περὶ τὰς ῥῖνας. ὁ δὲ λέων τοῖς ἰδίοις ὄνυξιν ἔξυεν ἑαυτὸν, ἕως οὗ ἠγανάκτησεν· οὕτως ὁ κώνωψ ἐνίκησε τὸν λέοντα καὶ ἀπῆλθεν. ἔπεσε (from *πίπτω*) *δὲ εἰς τὸν ἀράχνης δεσμὸν καὶ ἀπωδύρετο* (from *ἀποδύρομαι*), *ὅτι ἐνίκησε λέοντα, ἰσχυρότατον θῆρα, ἀλλ' ἀπώλετο* (from *ἀπόλλυμι*) *ὑπὸ εὐτελοῦς ζώου, τῆς ἀράχνης.*

As practice in translation, the student might after a lapse of a few days write out the above in English.

NOTE. For the treatment of accents the student is referred to Rutherford's or Goodwin's Greek Grammar (Macmillan).

GREEK *concluded*

TABLE OF ROOT WORDS IN LATIN AND GREEK

With their Derivatives in English, French, Italian and Spanish.

By G K. Hibbert, M.A.

In English, French, Italian and Spanish, a great many words derived from the same Latin or Greek root-word undergo changes more or less consistent in all four languages Consequently, as a general rule, when we know the English word derived from the Latin or Greek, we can construct the corresponding word in French, Italian or Spanish, Below are set forth the most common rules in this connection These should be carefully noted, as in the list which we are giving only the *exceptions* to these rules will be noted That is to say, only when a word of Greek or Latin origin undergoes an irregular change in any of the other languages will that word be given. This will save the needless repetition of numerous words which the student, with these rules before him, can form for himself

It should be mentioned that German is not included in this list because German is largely Teutonic in its structure, and not (like French, Italian and Spanish) of Classical or Romance origin

The following scheme gives the principal rules for the respective languages, the English word being taken as the basis in each case

Nouns

A. Greek Derivatives

English Ending	*French*	*Italian*	*Spanish*
y	ie	ia	ia
(agony)	(agonie)	(agonia)	(agonia)
e	e	a	a
(parable)	(parable)	(parabola)	(parabola)
a	e	a	a
(asthma)	(asthme)	(asma)	(asma)
t, l, m, and most consonants	add e	add o	add o
ics	ique	ica	ica
(mechanics)	(mecanique)	(meccanica)	(mecanica)
ch	que	ca	ca
(monarch)	(monarque)	(monarca)	(monarca)
is	e	i	is
(crisis)	(crise)	(crisi)	(crisis)

B. Latin Derivatives

tor, sor, or, our, er	eur	ore	or
(doctor, emperor)	(docteur, empereur)	(dottore, imperatore)	(doctor, emperador)
ary	aire	ario	ario
(lapidary)	(lapidaire)	(lapidario)	(lapidario)
ate	at	ato	ado
(legate)	(legat)	(legato)	(legado)
age	age	ggio	aje
(voyage)	(voyage)	(viaggio)	(viaje)
ty	té	tà	dad
(vanity)	(vanité)	(vanità)	(vanidad)
ion	ion	ione	ion
(action)	(action)	(azione)	(accion)
ain	agne	agna	aña
(mountain)	(montagne)	(montagna)	(montaña)

Adjectives

A. Greek Derivatives

English Ending	*French*	*Italian*	*Spanish*
ic	ique	ico	ico
(cosmetic)	(cosmetique)	(cosmetico)	(cosmetico)
ac	aque	aco	aco
(maniac)	(maniaque)	(maniaco)	(maniaco)
an	e	a	a
(cosmopolitan)	(cosmopolite)	(cosmopolita)	(cosmopolita)

B. Latin Derivatives

al	al	ale	al
(general)	(général)	(generale)	(general)
ain	ain	o	o
(certain)	(certain)	(certo)	(cierto)
ar	ier	are	ar
(singular)	(singulier)	(singolare)	(singular)
ary, arious	aire	ario	ario
(gregarious, necessary)	(grégaire, nécessaire)	(gregario, necessario)	(gregario, necesario)
ian	ien	iano	iano
(Christian)	(Chrétien)	(Cristiano)	(Cristiano)
ine	in	ino	ino
(feminine)	(féminin)	(femminino)	(femenino)
ic	ique	ico	ico
(public)	(publique)	(pubblico)	(publico)
ous, ose	eux	oso	oso
(copious, verbose)	(copieux, verbeux)	(copioso, verboso)	(copioso, verboso)
acious	ace	ace	az
(loquacious)	(loquace)	(loquace)	(loquaz)
ive	if	ivo	ivo
(captive)	(captif)	(cattivo)	(cautivo)
estrial, estrian	estre	estre	estre
(terrestrial, equestrian)	(terrestre, equestre)	(terrestre, equestre)	(terrestre, ecuestre)

Verbs

A Greek Derivatives

English Ending	*French*	*Italian*	*Spanish*
ise, ize	iser	are	ar
(baptize)	(baptiser)	(battezzare)	(bautizar)

B Latin Derivatives

fy	fier	ficare	ficar
(edify)	(edifier)	(edificare)	(edificar)
ish	ir	ire	ir
(nourish)	(nourrir)	(nutrire)	(nutrir)
—	er	are	ar
	(demander)	(demandare)	(demandar)
—	re	ere	er
	(croire)	(credere)	(creer)
—	ir	ire	ir
	(vêtir)	(vestire)	(vestir)

There are, of course, many changes at the beginning or in the middle of words as they pass from one language to another, but these cannot be noted here in full A study of the following list will make the majority of these changes clear

Latin

(Note *F*—French, *I*=Italian, *S*=Spanish)

Acer, *sharp;* Acuo, *I sharpen:* acid, acrid, acrimonious, acute, acumen, acerbity, vinegar (sour wine). *F* âcre, aigu, aigre. *I* acre. *S* agudo.

Ædes, *house*. edify, edifice (facio = I make)

Æquus, *level* · equal, equity, equator, equivalent, equinox, adequate. *F* égal, équateur *I* uguale, equinozio. *S* igual, ecuador, equinoccio.

Æstimo, *I value* · estimate, esteem, aim. *I* stima (= esteem, noun).

Ævum, *age* · coeval, primeval.

Ager, *field:* agriculture, agrarian. *I* agrimensore (land-surveyor). *S* agrimensor.

AGO, *I drive, I do:* act, agent, agile, agitate, exigent, cogent, cogitate, litigation. *F* agir (to act). *I* atto (an act). *S* accion.

ALBUS, *white*: album, albumen, Albion, albino. *F* aube (alb). *I* albeggiante (whitish). *S* albar.

ALIUS, *other;* ALTER (*the other of two*): alias, alibi, alien, alter, alternate, "alter ego," altruism. *F* autre. *I* altrui, altrove, altramente. *S* otro.

ALTUS, *high, deep:* alto, altitude, exalt. *F* altier (haughty). *I* alto, altura, altero. *S* alto, altivo.

AMBULO, *I walk:* amble, perambulator, somnambulist, ambulance. *I* amb.o. *S* amblar.

AMO, *I love:* amour, amorous, amateur, amatory, amicable, inimical, amiable, amenity. *F* aimer. *I* amore. *S* amor, amigo.

ANGO, *I choke:* anger, anguish, anxiety, angina pectoris. *F* angoisse. *I* angore, ansieta. *S* ansia.

ANIMA, *breath:* animal, animate. ANIMUS, *mind:* animadvert, magnanimous, unanimous.

ANNUS, *year*: annual, annuity, anniversary, millennium, perennial, biennial, centenary, solemn. *F* année. *I* anno, perenne. *S* año.

APERIO, *I open:* April, aperture, aperient. *F* Avril, apéritif. *I* Aprile, apritivo, apriporta (door-opener). *S* Abril, abertura.

AQUA, *water:* aquarium, aquatic, aqueduct. *F* eau, aquarelle (painting in water-colours). *I* acqua, acquidotto. *S* agua.

ARDEO, *I burn:* ardent, arson, ardour.

ARTUS, *a joint:* article (a little joint), articulate. *I* articolo. *S* articulo.

AUDEO, *I dare:* audacious. *S* audaz.

AUDIO, *I hear:* audience, audible, audit. *F* auditoire, audition. *I* udire. *S* oir.

AUGEO, *I increase:* augment, auction, author, authority. *F* auteur, octroi. *I* aumentare, autore.

AURIS, *ear:* aurist, auricular. *F* oreille. *I* orecchio. *S* oreja.

AURUM, *gold:* auriferous, aureole, oriole, oriel. *F* or. *I* oro. *S* oro.

AVIS, *bird:* aviary, auspicious (auspice = avispicium, drawing an omen from watching birds).

BARBA, *beard:* barb, barber, barbel. *F* barbon (grey-beard, dotard). *I* barbone.

BELLUM, *war:* duel (original form of *bellum* was *duellum*), bellicose, belligerent, rebel, revel. *F* belliqueux. *I* ribelle. *S* belico.

BENE, *well:* benefit, benign, benediction, benevolence.

BIS, *twice:* biscuit, bi-sect, bi-furcate, biceps, binocle, binomial, combine. *F* bis (encore !).

BONUS, *good:* bon-bon, bonny, bonus. *F* bien, bon. *I* bene, buono. *S* bien, bueno.

BREVIS, *short*: brief, brevity, breviary, semibreve, brevet. *F* bref. *I* and *S* breve.

CADO, *I fall*: cadaverous, cadence, cascade, chance, case, casual, casuistry. ac-cident, oc-cident, oc-casion. *F* cas. *I* and *S* caso. *S* caer (to fall).

CÆDO, *I cut, I kill:* homicide, suicide, incision, concise, circumcision.

CÆLUM, *heaven, sky:* celestial, ceiling. *F* ciel. *I* and *S* cielo.

CANDEO, *I shine:* candid (= white), candidate (at Rome applicants for office dressed in white), candle, in-cendiary. F chandelle, incendie (fire). *I* and *S* candela, incendio.

CANO, *I sing:* chant, incantation, recant, canticle, cantata, canto. *F* chanter. *I* cantare.

CAPIO, *I take:* captive, caitiff, capable, capacity, accept, receptive, receive, conceit, capstan. *F* recevoir, cabestan. *I* cattivo, ricevere. *S* cautivo, recibir.

CAPUT, *head:* capital, cape, capitulate, captain, chief, chapter. *F* capitaine, chef, chapitre. *I* capitano, capo, capitolo. *S* capitan, cabeza, capitulo.

CARO (gen. *carnis*), *flesh:* carnage, carnal, carnation, incarnation, carnival, carnivorous. *F* chair. *I* and *S* carne.

CAUSA, *cause:* cause, excuse, accuse, recusant.

CEDO, *I go, I yield:* cede, cession, recede, abscess, success. *F* céder. *I* cedere.

CENTUM, *a hundred*: cent, century, centipede. *F* cent, centime. *I* cento, centinaio. *S* ciento.

CERNO, *I distinguish:* discern, concern, discreet, secret (from the supine *cretum*). *I* segreto.

CHARTA, *paper:* chart, charter, card, carte, cartoon, cartridge. *F* carte. *I* and *S* carta.

CIVIS, *citizen:* civic, civil, city. *F* cité, citoyen. *I* citta. *S* ciudad.

CLAMO, *I shout:* clamour, claim, proclaim, reclaim. *I* chiamare, clamare (to call).

CLARUS, *bright:* clear, claret, clarion, clarify. *F* clair. *I* chiaro.

CLAUDO, *I shut:* clause, close, closet, cloister, include, conclude, preclude. *F* clos, cloître. *I* chiuso, chiostro. *S* claustro.

COLO, *I till:* cult, culture, cultivate, colony. *I* and *S* culto (worship).

CONTRA, *against:* country, counter, counterfeit, countermand, contrast, contrary, contradict.

COQUO, *I boil:* cook, concoct, decoction. *I* cuoco. *S* cocinero.

COR, *heart:* cordial, concord, record. *F* cœur. *I* cuore. *S* corazon.

CORPUS, *body:* corporation, corps, corpse, corpulent, incorporate, corporal. *I* corpo. *S* cuerpo.

CREDO, *I believe:* creed, credit, incredible. *F* croire, croyance. *I* credo, credenza. *S* creer.

CRESCO, *I grow* (supine, *cretum*): crescent, increase, concrete, recruit. *F* croître, croissant. *S* crecer.

CRUX, *cross:* crucial, crucible, crucifix, crusade, *F* croix, croisade. *I* croce, crociata. *S* cruz.

CURA, *care:* cure, curate, curator, curious, sinecure, procure, proctor (= procurator), secure, sure. *S* cuidado.

CURRO, *I run:* cursive, cursory, current, corridor, curriculum, course, discourse, concourse, concur, recur, incur. *F* courir. *I* correre. *S* correr.

DEBEO, *I owe:* debit, debt, due, duty, debenture. *F* devoir, dette. *I* dovere, debito. *S* deber.

DECEM, *ten:* December, decimal, decimate. *F* dix. *I* dieci. *S* diez.

DENS, *tooth:* dent, dentist, trident. *S* diente.

DEUS, DIVUS, *god:* deity, deify, divine, divinity. *F* dieu. *I* dio. *S* dios.

DICO, *I say:* diction, dictate, predict, contradict. *F* dire. *I* dire. *S* decir.

DIES, *day:* diary, diurnal, quotidian, adjourn, journal, journey. *F* jour. *I* giorno. *S* dia.

DIGNUS, *worthy:* deign, dignity, disdain, condign. *I* degno.

DO, DONO, *I give, I put.* donation, con-done, pardon, date, add (ad-do), e-dit. *F* donner. *I* dare.

DOCEO, *I teach:* docile, document, doctor, doctrine. *I* dottore.

DOMINUS, *lord:* dominate, domain, dame (= domina), domino, dominie. *F* dimanche (=dies dominica, the Lord's Day). *I* domenica. *S* duenna.

DOMUS, *home:* domicile, domestic, dome.

DORMIO, *I sleep:* dormant, dormouse, dormitory.

DUCO, *I lead:* duke, duct, educate, conduce, reduction. *F* duc, conduire. *I* duca, condurre. *S* duque, conducir.

DULCIS, *sweet:* dulcet, dulcimer. *F* doux. *I* dolce. *S* dulce.

DUO, *two*: duet, dual, dubious, doubt. *F* deux. *I* due. *S* dos.

EMO, *I buy,* SUMO, *I take,* (sub-emo): redeem, exempt, ransom, consumption, presume, assume.

Eo, Itum, *I go:* exit, exeunt, transit, trance, issue, itinerate, obituary, initial, perish. **Comes** = companion, one who goes with: count, concomitant.

Equus, *horse:* equine, equestrian.

Faber, *workman:* fabric, fabricate, forge. *I* fabbro (forger).

Facio, *I make:* fact, feat, faction, face, superficial, defeat, infect, comfit, confectioner, fortify, defy, efficient. *F* faire, fait. *I* fare, fatto. *S* hacer, hecho.

Fallo, *I deceive:* false, infallible, falter, fail, fall, fault. *F* faillir, faux. *S* faltar.

Fero, *I bear* (supine *latum*): fertile, suffer, transfer, translate, legislate, dilate, confer, vociferous. *I* trasferire.

Ferveo, *I boil:* fervent, ferment, effervesce. *S* hervir.

Fido, *I trust:* fidelity, fiduciary, confide, perfidy, defy. *F* foi (faith). *I* fede. *S* fe.

Fingo, *I shape:* fiction, feign, figure. *F* feindre. *I* finzione. *S* ficcion.

Finio, *I end:* fine, final, finish, finite, infinite, define, infinitive.

Fiscus, *purse, treasury:* fiscal, confiscate.

Flagro, *I burn:* flagrant, conflagration, flame, inflammation. *I* fiamma. S flama.

Flo, *I blow:* flatulent, inflate. *F* enfler. *I* enfiare.

Flos, *flower:* florid, florist, flourish, flour, efflorescence. *F* fleur. *I* fiore. *S* flor.

Fluo, *I flow:* fluid, flux, fluctuate, fluent, affluent, confluence, influence, influx.

Fœdus, *a treaty* (akin to fides, *faith*): federal, federation, confederate.

Folium, *leaf:* foil, foliage, folio, trefoil. *F* feuille. *I* foglia. *S* hoja.

For, Fans, Fatum, *I speak:* fame, infamous, fate, fatal, infant, confess, nefarious.

Fortis, *strong:* fort, fortress, forte, fortify, fortitude, comfort. *S* fuerte.

Frango, *I break:* fragment, fracture, fraction, fragile, frail, infraction, refraction, infringe.

Frater, *brother:* friar, fraternity, fraternal, fratricide. *F* frère. *I* fratello, fra.

Frons, *brow:* front, frown, affront, confront, frontage, frontier, frontispiece.

Fruor, *I enjoy:* fruit, fruition, frugal, usufruct. *I* frutto. *S* fruto.

Fugio, *I flee:* fugitive, fugue, refuge, subterfuge. *F* fuir. *I* fuggire. *S* huir.

Fundo, *I pour:* funnel, foundry, confound, confuse, refund; refuse, fuse, futile, fountain, font.

Fundus, *bottom:* fund, fundamental, foundation. *F* fond. *I* and *S* fondo.

Fungor, *I perform:* function, perfunctory.

Gelo, *I freeze:* gelid, gelatine, galantine, jelly, congeal. *F* gelée. Also **Glacies**, *ice:* glacier, glacé, glass. *I* ghiaccio (ice). *S* hielo.

Gero, *I bear:* gerund, gesture, gesticulate, jest, suggest, digest, vice-gerent, belligerent, register.

Gradior, *I step:* grade, graduate, gradual, digress, transgress, egress, aggression, degrade, degree.

Gravis, *heavy:* grave, gravid, gravity, grief.

Grex, *flock:* gregarious, egregious, congregation. *I* gregge.

Gusto, *I taste:* gusto, disgust. *F* goût. *I* and *S* gusto.

Habeo, *I have:* habit, have, exhibit, inhibit, prohibit. *F* avoir. *I* avere. *S* haber. Also a frequentative form, **Habito**, *I dwell:* inhabit, habitation, haunt, cohabit.

Hæreo, *I stick:* adhesive, hesitate, cohere.

Homo, *man:* homicide, human, humane, humanity. *F* homme. *I* uomo. *S* hombre.

Horreo, *I bristle:* horrid, horror, horrible, abhor.

Hospes, *guest:* hospital, hospice, hospitable, host, hostel, hotel. *I* ospedale. *S* huesped.

Hostis, *enemy:* host, hostile. *S* hueste.

Humeo, *I am moist:* humid, humour.

Humus, *ground:* humble, humiliate, exhume. *I* umile. *S* humilde.

Idem, *same:* identity, identify, identical.

Ira, *anger:* ire, irascible, irate.

Jacio, *I throw:* ejaculate, object, reject, adjective, conjecture, projectile, jet, jetsam. *F* jeter. *I* gettare. *S* echar.

Judex, *judge:* judicial, adjudicate, prejudice. *F* juge. *I* giudice. *S* juez.

Jungo, *I join:* juncture, junction, joint, conjunction, injunction. *F* joindre. *I* giungere. *S* juntar.

Juro, *I swear:* jury, conjure, adjure, perjury. *I* giuri. *S* jurado.

Jus, *law:* just, jurisdiction, jurisprudence, injure. *I* giusto.

Juvo, *I help:* adjutant, jury (mast).

Labor, *I glide:* lapse, collapse, relapse.

Lædo, *I hurt:* lesion, elide, collide, lèse-majestie.

Lapis, *stone:* lapidary, lapis lazuli, dilapidate.

Lavo, *I wash:* lave, lavatory, lotion, lava, lavender, lavish, laundry. *F* laver. *I* lavare.

Lego, *I gather, I choose, I read:* neglect, collect, elect, intelligent, lecture, lesson, college, legion, legend, legible. *F* lire. *I* leggere. *S* leer.

Lego, *I depute:* legacy, legatee, legation, relegate. *F* legs.

Leo, *lion:* leonine, leopard, Leonard, Leander.

Levo, *I lift:* levity, levy, Levant, elevator, levée, lever, relieve, alleviate, legerdemain.

Lex, *law:* legal, legitimate, legislate, privilege. *F* loi. *I* legge. *S* ley.

Ligo, *I bind:* religion, obligation, league, ligature, ligament, colligate. *F* lier. *I* legare.

Linquo, *I leave:* delinquent, relinquish, relict, derelict.

Litera, *letter:* literal, literary, literature, illiterate. *F* lettre. *I* lettera. *S* letra.

Locus, *place:* local, locate, locomotive, locum tenens. *F* lieu. *I* luogo. *S* lugar.

Loquor, *I speak:* eloquent, colloquy, loquacious, elocution, magniloquent, soliloquy.

Luceo, *I shine:* lucid, elucidate, lucent, lunar, lunatic, luminary, illumine. *F* luire. *I* lucere.

Ludo, *I play:* elude, prelude, delude, collusion, illusion, ludicrous.

Magnus, *great:* main, magnate, magnify, magnitude, majesty, major, mayor, magistrate, master. *F* maire, maître *I* and *S* maestro.

Malus, *bad:* malady, malaise, mal-de-mer, malaria, malefactor, malevolent, maltreat, malice, malignant, malinger.

Maneo, *I remain:* mansion, manse, manor, menial, remain, remnant, permanent. *F* maison.

Manus, *hand:* manual, manufacture, manuscript, manicure, manifest, manipulate, manœuvre, emancipate, maintain. *F* main. *I* and *S* mano.

Mater, *mother:* maternal, matricide, matriculate, matrimony, matron. *F* mère. *I* and *S* madre.

Medeor, *I heal:* medicine, medicate, remedy. *F* médecin (doctor). *I* medico.

Medius, *middle:* median, mean, medium, meridian, medieval, mediocre, Mediterranean, immediate. *F* moyen, milieu. *I* mezzo.

Memor, *mindful:* memoir, memorable, memory, commemorate, remember.

Metior, Mensus, *I measure:* mensuration, commensurate, immense. *I* misurare. *S* medir.

Miles, *soldier:* military, militia, militant, militate. *S* militar.

MILLE, *thousand*: mile, millennium, million, millimetre. *F* and *S* mil. *I* mille.

MINUO, *I lessen*: minus, minor, minim, minimise, diminish, minute, minister, minstrel, minuet, minutiæ. *F* moins, menu. *I* minore. *S* ménos.

MIROR, *I wonder at, I admire*: mirror, mirage, miracle, admire, marvel.

MITTO, *I send, I put*: mission, missile, missive, admit, permit, remiss, omit, promise, demise. *F* mettre. *I* mettere.

MONEO, *I warn*: monitor, monster, monument, demonstrate, remonstrance, admonish, summon.

MONS, *mountain*: mount, mound, surmount, amount, promontory. *F* montagne. *I* montagna. *S* monte.

MORIOR, *I die*: moribund, mortal, mortuary, mortgage, mortify, mortmain. *F* mourir. *I* morire.

MOVEO, *I move*: motion, motor, mobile, mob, moment, motive, emotion, promote, mutiny. *F* mouvoir. *I* muovere.

MULTUS, *many*: multiply, multitude, multifarious. *I* molto. *S* mucho.

MUTO, *I change*: mutation, mutable, permutation, commute, mutual.

NASCOR, *I am born*: nascent, renaissance, native, nature, nation, natal, Noel, cognate. *F* naître, née. *I* nascere. *S* nacer.

NAUTA, *sailor*: NAVIS, *ship*: nautical, nautilus, navy, navigate, navvy. *F* navire. *I* and *S* nave.

NEGO, *I deny* (nec, *not*: aio, *I affirm*): negative, negation, renegade, runagate.

NEPOS, *grandson*: nephew, nepotism. *F* neveu. *I* nipote.

NOCEO, *I hurt*: noxious, nocuous, noise, innocent, obnoxious. *F* nuire. *I* nuocere.

NOMEN, *name*: NOSCO, *I know*: NOBILIS, *known, noble*: noun, nominate, nomenclature, nominal, binomial, ignominy, gnostic, note, notion, notice. *F* nom, con-naître. *I* nome, conoscere. *S* nombre.

NOVUS, *new*: novel, novelty, novice, innovation, renovate, nuncio, announce. *F* neuf, nouveau. *I* nuovo. *S* nuevo.

NUBO, *I marry* (lit. *I veil myself*, connected with nubes = cloud): nuptial, connubial. *F* noces. *I* nozze. *S* nucias.

OCTO, *eight*: octogenarian, octave, October. *F* huit. *I* otto. *S* ocho.

OCULUS, *eye*: oculist, binocular, ocular. *F* œil, aveugle. *I* occhio. *S* ojo.

OMNIS, *all*: omnivorous, omnipotent, omniscient, omnibus, "omnium-gatherum." *I* ognuno.

OPTIMUS, *best*: optimist, optimates, "Senior Op." (at Cambridge). *I* ottimo.

OPTO, *I choose*: option, adopt, co-opt, optative.

OPUS, *work*: opera, operate, co-operative. *F* œuvre. *S* obra.

ORBIS, *circle*: orb, orbit, exorbitant.

ORDO, *rank*: ordinary, order, ordain, ordinance.

ORIOR, *I rise*: orient, origin, abortion.

ORO, *I speak, I pray*: oral, oracle, orison, oration, peroration, inexorable, adore.

OVUM, *egg*: oval, ovary, oviparous, ova, ovule. *F* œuf. *I* uovo. *S* huevo.

PANDO, *I spread*: pace, pass, passenger, expand, expanse, compass. *F* pas. *I* passo. *S* paso.

PANGO, *I fix*: pagan (from pagus = district), peasant, page, pageant, compact, impact, impinge. *F* païen, pays, paysan. *I* paese (country). *S* país.

PAR, *equal*: peer, pair, umpire, compare, compeer, parisyllabic. *F* pair, pareil. *I* pari.

PAREO, *I come forth*: appear, apparent, apparition.

PARIO, *I bring forth*: parent, parturition, oviparous, viviparous, viper, repertory.

PARO, *I make ready*: pare, parry, prepare, repair.

PARS, *part*: parse, partial, participate, particular, particle, participle, partisan, partition, party, repartee, impart, portion.

PASCO, *I feed*: pastor, pasture, repast. *F* paître.

PATER, *father*: paternal, patron, parricide, patriarch, patrimony, patriot, expatriate. *F* père. *I* and *S* padre.

PATIOR, *I suffer*: patience, passion, passive.

PELLO, *I drive*: push, pulse, compel, impel, repel, impulsive, repulsive. *F* pousser.

PENDEO, *I hang, I weigh*: pensive, pension, pendant, pendulum, suspense, depend, compensate, recompense, perpendicular, pound, ponder, poise.

PES, *foot*: pedal, pedestrian, pedestal, biped, impede, expedite, expedient. *F* pied. *I* piede. *S* pié.

PETO, *I seek*: petition, petulant, compete, appetite, repeat.

PLACEO, *I please*: plea, placid, placable, pleasant, complacent. *F* plaire. *I* piacere.

PLAUDO, *I clap, I praise*: plaudit, plausible, applaud, explode.

PLEO, *I fill*: plenary, plenipotentiary, plenty, replenish, replete, complete, supply, supplement, complement. *F* plein. *I* pieno. *S* lleno.

PLICO, *I fold*: ply, pliable, pliant, plight, apply, duplicate, double, duplicity, complicate, complex, supplicate. *F* plier. *I* piegare. *S* plegar.

PLUS, *more*: plural, pluperfect, surplus.

PONO, *I place*: post, position, positive, posture, deponent, deposit, composition, supposition, impost, compound, postpone.

POPULUS, *people*: population, popular, public, publish. *F* peuple. *S* pueblo.

PORTO, *I carry*: porter (= one who carries; but porter = doorkeeper, is from porta = door), port (= demeanour), portfolio, export, important.

POSSUM (potis-sum), *I am able*: possible, posse, potent, potentate, impotent.

POTO, *I drink*: potation, potable, potion, poison. *I* potare.

PREHENDO, *I grasp*: prehensile, apprehend, comprehensive, comprise, prison, prize (= reward). *F* prendre.

PREMO, *I press*: express, oppress, impress, print.

PRETIUM, *value*: price, precious, prize (= valuation, estimate). *F* prix. *I* prezzo. *S* precio.

PRIMUS, *first*: prim, prime, primate, premier, primeval, primrose, primitive, prince, principal, principle. *F* premier. *I* primo.

PUNGO, *I prick*: puncture, pungent, point, pounce, expunge, punctilious, punctual, punctuate.

PUTO, *I cut, I think*: putative, amputate, compute, count, reputation, deputy.

QUÆRO, *I seek*: query, quest, question, require, exquisite, inquisition. *S* cuestion.

QUATIO, *I shake* (in compounds cutio, cussum): quash, discuss, concussion, percussion.

QUOT, *how many*: quote, quotient, quota, quotidian. *S* cociente.

RAPIO, *I snatch*: rapacious, rape, rapid, rapine, rapt, rapture, ravage, ravish, ravenous, ravine. *F* ravir. *I* rapire.

REGO, *I make straight, I rule*: regent, regal, royal, regnant, reign, regicide, regiment, regular, rector, rectify, direct, correct. *F* roi (king). *I* re. *S* rey.

ROGO, *I ask*: rogation, derogatory, arrogate, abrogate, interrogative, prorogue

RUMPO, *I break*: rupture, eruption, corrupt, disruption, bankrupt, abrupt, interrupt. *F* rompre. *I* rompere.

SAL, *salt*: salad, saline, salary, sausage. *F* sel. *I* sale. *S* sal.

Salio, *I leap:* salient, sally, salmon, assail, assault, insult, exult, result. *F* saillir. *I* saltare

Salus, *health:* salute, salutary, salubrious, salvation, salvage, saviour, safe, save, sage (the plant). *F* sauf (= safe). *I* salvo.

Sapio, *I taste:* savour, sapient, sage (= wise), insipid. *I* sapere. *S* sapido (= high-flavoured).

Scio, *I know:* science, omniscient, conscious.

Scribo, *I write:* scrip, script, scripture, scribe, describe, conscription, postscript, scribble, scrivener. *F* écrire, escritoire. *I* scrivere. *S* escribir.

Seco, *I cut:* section, sect, dissect, bisect, segment, insect, intersect.

Sedeo, *I sit:* sediment, sedentary, session, possess, sedate, sedulous, preside, *F* as-seoir.

Senex, *old man:* senile, senior, sir, sire, senate. *F* sieur. *I* signore. *S* señor.

Sentio, *I feel:* sense, sentient, sentence, sentiment, assent, consent, scent.

Sequor, *I follow:* sequence, sequel, sequestrate, consequence, consecutive, persecute, second, sue, suit, pursuit. *F* suivre, suite. *I* seguire. *S* seguir.

Sero, *I join:* series, serial, sermon, insert, desert, exert, assert.

Servio, *I serve:* serf, servile, servant, sergeant, dessert, deserve.

Similis, *like:* **Simul**, *at the same time:* similar, simile, simulate, simultaneous, assimilate, semblance, resemble. *F* sembler.

Solvo, *I loosen, I pay:* solve, solvent, soluble, solution, dissolute, absolute, resolve.

Sono, *I sound:* sonorous, sonata, sonnet, resonant, consonant, unison, person, parson. *F* sonner.

Specio, *I look:* spy, species, specious, special, spice, specimen, specify, spectacle, spectre, speculate, aspect, respect, conspicuous, perspective, suspicion, prospectus, despise. *F* épier. *I* specchiare. *S* espiar.

Spiro, *I breathe:* spirit, spirant, aspirate, conspire, inspiration, respirator, perspire.

Spondeo, *I pledge:* sponsor, spouse, responsible, despond. *F* épouse. *S* esposa.

Sterno, *I lay down:* strata, street, strath, stray, strew, prostrate, consternation.

Sto, *I stand:* stable, stage, stamina, stanza, state, station, statue, extant, distant, constant, substance, obstacle, destination. *F* état. *S* estado.

Stringo, *I draw tight:* string, stringent, strict, strait, strain, constraint, restrain, distrain, distress, district, boa-constrictor. *F* étroit. *I* stretto. *S* estrecho.

Struo, *I pile up:* structure, construct, destroy, construe, instruction. *F* construire. *I* costruire.

Super, *above:* superior, superintend, supreme, sum, summit, surface, surfeit, survive. *F* sur. *I* sopra. *S* sobre.

Surgo, *I rise:* surge, source, resurrection, resource, insurrection, insurgent.

Tango, *I touch:* tangent, tangible, tact, contact, contagious, contiguous, attain, intact, integral, integrity. *F* atteindre. *I* tatto, contatto.

Tego, *I cover:* tile, detective, protect, integument. *I* tegola (tile). *L* tectum (= roof). *S* teja.

Tempus, *time:* tense, temporal, contemporary, extemporary. *F* temps. *I* tempo. *S* tiempo.

Tendo, *I stretch:* tend, tense (= tight), tension, tentacle, tent, tentative, contend, intent, intend, intense, tempt, taunt, "tenter-hooks."

Teneo, *I hold:* tenable, tenacious, tenant, tenement, tenet, tenor, tenure, maintain, retain, retinue, continent, content, continuous. *F* tenir.

Tero, *I rub:* trite, triturate, tribulation, contrite, contrition, attrition. *I* tritico (corn).

Terra, *earth:* terra-cotta, terrace, terrestrial, terrier, territory, inter, Medi-terranean, tureen. *S* tierra.

Texo, *I weave:* text, texture, textile, context, pretext, tissue. *F* tisser. *I* tessere. *S* tejer.

Torqueo, *I twist:* torch, torment, torsion, tort, tortoise, tortuous, torture, contortion, retort. *F* tort (wrong). *I* torto. *S* torcer (to twist.)

Traho, *I draw:* trace, tract, trail, train, trait, treat, tare and "tret," attract, retreat, portrait.

Tres, *three:* trefoil, triangle, trident, trinity, trio, trivet, trivial. *F* trois. *I* tre. *S* tres.

Turba, *crowd:* turbid, turbine, turbulent, perturbation, disturb.

Unda, *wave:* undulate, Undine, abound, abundant, redound, inundate. *F* onde. *I* and *S* onda.

Unus, *one:* unit, unique, union, unicorn, uniform, universe, university, triune. *F* un. *I* uno.

Valeo, *I am strong:* valid, invalid, valerian, valiant, valour, value, avail, prevalent, convalescent. *F* valoir. *I* valetudine (health).

Veho, *I carry:* vex, veil, vein, vehicle, convey, convex, inveigh, invective, reveal. *F* voile, voiture (carriage). *I* vettura.

Venio, *I come:* venture, adventure, convene, convent, convention, supervene, prevent, revenue, avenue, convenient, covenant. *F* venir.

Verto, *I turn:* versatile, verse, vertebra, vortex, vertex, vertigo, convert, perverse, aversion, inversion, reversion, obverse, adverse, advertise, conversant, divorce.

Verus, *true:* very, verily, verity, verify, verdict, veracity, aver. *F* vrai. *I* vero. *S* verdad (truth).

Via, *road:* viaduct, devious, voyage, impervious, trivial, obvious, previous, obviate. *F* voie. *I* and *S* via.

Video, *I see*. viz. (short for "videlicet"), view, visage, vision, visible, visit, vista, provide, providence, prudence, revise, survey, envy, invidious, evident. *F* voir. *S* ver.

Vinco, *I conquer:* victor vanquish, convict, convince, evince, eviction, province (?). *F* vaincre. *S* vencer.

Vivo, *I live:* vivid, vivacious, vivisect, victuals, vital, revive, survival, convivial, viper (= vivipara, producing young alive). *F* vivre. *S* vivir.

Voco, *I call:* vocal, voice, vouch, vociferous, vocation, vocative, vocabulary, vowel, invoke, convocation. *F* invoquer.

Volvo, *I roll:* voluble, volume, revolve, convolution, involve, devolution.

Voveo, *I vow:* votive, votary, vote, devote, devout. *F* vouer. *I* votare.

Greek

In the process of anglicising a Greek word the following changes should be noted:

Greek υ (*u*) becomes English *y*, as συ τάξις, *suntaxis* (syntax).

Greek αι (*ai*) becomes English *æ*, as αἴσθησις, *aisthēsis* (æsthetic).

Greek οι (*oi*) becomes English *œ*, as οἶκος, *oikos* (œcumenical).

Greek γγ (*gg*), or γκ (*gk*), or γχ (*gch*), or γξ (*gx*) becomes English *ng, nk, nx,* as ἄγγελος, *aggelos.* (angel); ἄγκυρα, *agkura, ancura* (anchor).

[For the letters of the Greek alphabet and their English equivalents, see page 5374.]

Aēr (ἀήρ), *air:* aeronaut, aerolite. *F* aeronaute, aerolithe. *I* aeronauta, aerolito.

Agō (ἄγω), *I lead:* *E* pedagogue, synagogue, demagogue, strategy (stratos = army). *I* pedagogo, sinagoga, strategia. *S* estrategia.

AGŌN (ἀγών), *struggle :* agony, antagonist, protagonist, "Samson Agonistes" (Samson the struggler *or* wrestler). *F* agonie. *I* and *S* agonia.

AKROS (ἄκρος), *top, point :* acrobat (batos = walker, goer), acropolis, acrostic (stichos = a line). *I* acrobato, acrostico.

ALLOS (ἄλλος), *other :* allopathic, allotropy.

ANGELOS (ἄγγελος), *messenger :* angel, evangel. *F* ange, évangile. *I* angelo, evangelio.

ANTHRŌPOS (ἄνθρωπος), *man :* philanthropic, misanthrope, anthropology. *I* filantropico, misantropo, antropologia.

ARCHĒ (ἀρχή), *beginning, rule :* anarchy, archæology, archaic, monarch, archbishop, architect. *F* archevêque. *I* monarca, arcivescovo, architetto. *S* arzobispo, arquitecto.

ASTĒR (ἀστήρ), *star :* aster, asterisk, astronomy, astrology. *F* astérisque, astérie. *I* and *S* asterisco.

AUTOS (αὐτός), *self :* automobile, autobiography, autocar, autonomy, autocrat, authentic.

BALLŌ (βάλλω), *I throw :* parable, parabola, emblem, hyperbole, sym-bol, embolism. *I* iperbola, simbolo.

BAPTŌ (βάπτω), *I dip :* baptism, baptize. *F* baptême, baptiser. *I* battesimo, battezzare. *S* bautisme, bautizar.

BAROS (βαρος), *weight :* baritone, barometer, baroscope, isobar (isos = equal). *F* baromètre.

BIBLOS (βιβλός), *paper, book :* Bible, bibliography, bibliophile. *F* bibliothèque (library). *I* Bibbia, biblioteca (library).

BIOS (βίος), *life :* biology, biography, bioscope, microbe, amphibious. *F* amphibie. *I* and *S* anfibio.

CHOROS (χορός), *dance :* chorus, choir, chorister. *F* chœur, choriste. *I* and *S* coro, corista.

CHRONOS (χρόνος), *time :* chronology, chronometer, anachronism, chronic, chronicle. *I* cronologia, cronico, cronica.

CHRIŌ (χρίω), *I anoint :* Christ, Christian. *F* chrétien. *I* and *S* Cristo, cristiano.

CHRUSOS (χρυσός), *gold :* chrysalis, chrysoprase, chrysanthemum, chrysolite. *F* chrysalide. *I* crisalide.

DĒMOS (δῆμος), *people :* democracy, demos, demotic. *F* démocratie. *I* democrazia.

DOGMA (δόγμα), *opinion ;* DOXA (δόξα), *opinion, glory :* both from DOKEŌ (δοκέω), *I think :* dogma, orthodoxy, heterodoxy, doxology. *I* domma, ortodossia, eterodossia, dossologia.

DUNAMIS (δύναμις), *power :* dynamite, dynamics, dynasty

ĒLEKTRON (ἤλεκτρον), *amber :* electricity (because first observed in amber). *I* elettricita. *S* electricidad.

ERGON (ἔργον), *work :* energy, erg, metallurgy.

EU (εὖ), *well :* eucalyptus (*lit.* well-covered), euphemism, eucharist, euphony, eulogy, evangel. *F* eucharistie, évangile. *I* eucaristia, eufonia.

GASTĒR (γαστήρ), *stomach :* gastric, gastritis, gastronomy.

GĒ (γῆ), *earth :* geography, geology, apogee, giant (*lit.* earth-born). *F* géant. *I* and *S* gigante.

GENOS (γένος) *race, birth :* genealogy, oxygen, hydrogen (GENNAŌ, γεννάω, *I produce*), Genesis. *F* Genèse. *I* ossigeno, idrogeno, Genesi.

GIGNŌSKŌ (γιγνώσκω), *I know :* diagnosis, gnostic, a-gnostic, physiognomy (*cf.*, *L* cognosco).

GRAPHŌ (γράφω), *I write :* grammar, graphic, paragraph, telegram, epigram, graphite, graphoscope, cinematograph (*kinema* = movement). *F* grammaire. *I* grammatica. *S* gramatica.

HĒLIOS (ἥλιος), *sun :* heliotrope, heliograph, helium.

HEMI (ἡμι-), *half :* hemisphere, hemistich (*L* semi-). *I* emisfero.

HEPTA (ἑπτά), *seven :* heptarchy, heptagon. *I* ettarchia, ettagono. *S* heptarquia.

HETEROS (ἕτερος), *other :* heterodox, heteroclite, heterogeneous. *F* hétérogène. *I* eterogene.

HEX (ἕξ), *six :* hexameter, hexagon. *L* sex. *I* esagono. *S* exagono.

HIEROS (ἱερός), *sacred :* hieroglyphic, hierarchy. *I* geroglifo, gerarchia. *S* geroglifico, gerarquia.

HIPPOS (ἵππος), *horse :* hippodrome, hippopotamus (river-horse), Phil-ip (short for Philippos, *lover of horses*). *I* Filippo. *S* Felipe.

HOMOS (ὁμός), *same :* homogeneous, homologous. *F* homogène, homologue. *I* omogeneo, omologo.

HŌRA (ὥρα), *hour :* horology, horoscope. *F* horloge. *cf.* *L* hora. *I* orologio *S* reloj.

HUDŌR (ὕδωρ), *water :* hydrogen, hydrophobia, hydrostatics, hydraulic, dropsy. *F* hydropisie (dropsy). *I* idropisia (dropsy), idrofobia.

IDEIN (ἰδεῖν), *to see :* idea, idol, idyl, kaleidoscope. *F* idée, idole, idylle. *I* idea, idolo, idilio.

IDIOS (ἴδιος), *one's own*, or *peculiar :* idiot, idiom, idio-syncrasy (*idiot* originally meant *a private citizen*). *I* and *S* idiota, idioma.

KOSMOS (κόσμος), *order*, and so *the world* as opposed to chaos : cosmetic, cosmopolitan, microcosm.

KRINŌ (κρίνω), *I judge :* crisis, critic, hypocrite, hypercritical. *F* crise. *I* crisi *or* crise, ipocrita.

KRUPTŌ (κρύπτω), *I hide :* crypt, cryptogram, apo-crypha. *I* apocrifi.

KUKLOS, (κύκλος) *circle :* cycle, cyclometer, encyclopædia.

LAMBANŌ (λαμβάνω), *I take :* syl-lable, di-lemma, epi-lepsy. *F* syllabe. *I* sillaba, epilessia.

LEGŌ (λέγω), *I say, I choose :* lexicon, dialect, eclectic. *F* lexique. *I* lessico, dialetto. Also LOGOS (λόγος), *word :* logic, apology, geology, dialogue, syllogism, logarithm, tautology (tauto = the same).

LITHOS (λίθος), *stone :* lithography, monolith, lithia.

LUŌ (λύω), *I loosen :* para-lysis (palsy), analysis.

METRON (μέτρον), *measure :* metre, barometer, thermometer, metronome.

MĒTĒR (μήτηρ), *mother :* metropolis.

MIKROS (μικρός), *small :* microscope, microcosm, microbe (*lit.* small life): opposed to MAKROS, *large*, *e.g.*, macrocosm.

MISEŌ (μισέω), *I hate :* misanthrope, misogynist.

MONOS (μόνος), *alone, only :* monarch, monocle, monotony, monastery, minster, monotheism, monopoly [POLEŌ : I sell], monk. *F* moine (monk). *I* monaco (monk). *S* monje.

NAUS (ναῦς), *ship:* nautical, nautilus, nausea, aero-naut (nautes = a sailor).

NEKROS (νεκρός), *dead:* necropolis (a city of the dead, a cemetery), necromancy.

NOMOS (νόμος), *law:* astronomy, gastronomy, economy, Deuteronomy.

ONOMA (ὄνομα), *name:* syn-onymous, patronymic, onomatopœic, anonymous, pseudonym.

OPSIS (ὄψις), *sight:* optic, synopsis. *I* ottica.

ORTHOS (ὀρθός), *straight, right:* orthodox, orthography.

OXUS (ὀξύς), *sharp:* oxygen, oxytone, paroxysm. *I* ossigeno, parossismo.

PAIS (παῖς), *boy:* pedagogue; PAIDEIA, *instruction:* encyclopædia.

PAN (πᾶν), *all:* panto-mime, pantheist, panegyric, panacea, pandemonium, panorama. (*Panic* takes its name from the god Pan, who used to inspire terror.)

PATHOS (πάθος), *suffering:* pathos, pathetic, sympathy, apathy.

PENTE (πέντε), *five:* pentagon, pentateuch (teuchos = book), pentameter, pentecost (*fiftieth*). *F* pentecôte.

PEPŌ (πέπω), *I digest:* pepsine, peptonise, dys-peptic, "Peps."

PHAINŌ (φαίνω), *I show:* phenomenon, sycophant ("fig-shower"), phantasm, phantom, phase, emphasis. *F* fantaisie, fantôme. *I* enfasi (emphasis).

PHARMAKON (φάρμακον), *drug:* pharmacy, pharmaceutical, pharmacopœia. *I* farmaco (remedy).

PHĒMI (φημί), *I say:* blasphemy, blame, prophesy, aphasia (loss of speech). *I* bestemmia, biasimo.

PHERŌ (φέρω), *I bear:* phos-phorus (*lit.* light-bearer), metaphor (*cf.*, *L* fero = *I bear*).

PHILOS (φίλος), *fond of:* philosophy (sophia = wisdom), philanthropy, Philadelphia, Philip, philtre, biblio-phile.

PHŌNĒ (φωνή), *voice:* phonetic, telephone, phonograph, microphone, anthem (= anti, *against*, phonē, *voice*). *I* and *S* antifona.

PHŌS (φώς), *light:* phosphorus, photography, photophobia (dread of light).

PHRAZŌ (φράζω), *I speak:* phrase, paraphrase, periphrasis, phraseology. *I* and *S* frase.

PHRĒN (φρήν), *mind:* phrenology, frenzy, frantic. *F* frénésie, frénétique. *I* frenesia, frenetico.

PHTHIŌ (φθίω), *I waste away:* phthisis. *I* tisi *or* tisichezza (consumption). *S* tisis.

PHUSIS (φύσις), *nature:* (from PHUŌ, φύω, *I beget*): physics, metaphysics, physiology, physician, physiognomy.

PLANAŌ (πλανάω), *I cause to wander:* planet, aero-plane. *I* pianeta.

PNEUMA (πνεῦμα), *air, wind:* pneumatic, pneumonia. Greek for (Holy) *Spirit.* *S* neumatico.

POIEŌ (ποιέω), *I make:* poet, poem, poesy, pharmacopœia, onomatopœic.

POLIS (πόλις), *city:* policy, politics, metropolis, acropolis, cosmopolitan, police, Neapolis (Naples), Napoleon. *I* polizza (policy), polizia (police).

POLUS (πολύς), *many:* polyanthus, polygamy, polygon, polytechnic, polytheism, polypus.

POUS (πούς), *foot:* podagra (gout), tripod, trapeze, antipodes. *F* podagre.

PRESBUS (πρέσβυς), *old man:* presbyter, priest, Presbyterian. *F* prêtre. *I* prete. *S* presbitero.

PRŌTOS (πρῶτος), *first:* protagonist, protein, "protose," protocol, protoplasm, prototype.

PSALLŌ (ψάλλω), *I play the lyre:* psalm, psalter. *F* psaume, psautier. *I* and *S* salmo, salmista.

PSEUDĒS (ψευδής), *false:* all words beginning with *pseudo*, as pseudonym, pseudo Christian.

PSUCHĒ (ψυχή), *soul:* psychology, psychic (connected with PSYCHEŌ, *I breathe*). *I* psicologia. *S* psicologia.

PTŌMA (πτῶμα), *a fall*, (from PIPTO, *I fall*): ptomaine, ptosis, sym-ptom. *I* sintomo.

PUR (πῦρ), *fire:* pyramid, pyre, pyrites, pyrotechnics, empyrean. *F* empyrée.

RHĒGNUMI (ῥήγνυμι), *I break:* cataract, hæmorrhage. *I* cateratte. *S* catarata.

RHEŌ (ῥέω), *I flow:* rheum, rheumatism, catarrh, rhythm. *I* and *S* ritmo.

SCHOLĒ (σχολή), *leisure:* school, scholar. F école, écolier. *I* scuola, scolare. *S* escuela.

SKOPEŌ (σκοπέω), *I look, I view:* scope, bioscope, microscope, telescope, episcopal, bishop, sceptic. *F* évêque. *I* vescovo (bishop). *S* obispo.

STASIS (στάσις), *standing* (from HISTEMI, ἵστημι, *I make to stand*): ecstasy, apostasy, system, statics. *I* estasi.

STELLŌ (στέλλω), *I send:* epistle, apostle. *F* épître, apôtre. *I* epistola, apostolo.

STEREOS (στερεός), *solid:* stereoscope, stereotype.

STREPHŌ (στρέφω), *I turn:* catastrophe, apostrophe, strophe, antistrophe.

TAPHOS (τάφος), *tomb:* epitaph, cenotaph.

TAXIS (τάξις), *arrangement* (from TASSO, τάσσω, *I arrange*): taxidermist, syntax. *I* sintassi.

TEINŌ (τείνω), *I stretch:* tone, tonic, monotony, baritone, hypotenuse, protasis.

TĒLE (τῆλε), *afar:* telephone, telegraph, telepathy, telescope.

TEMNŌ (τέμνω), *I cut:* a-tom, epi-tome, tome, anatomy.

THEOS (θεός), *god:* theology, theosophy, theism, theocracy, apotheosis, enthusiasm(?) (*cf.*, *L* deus). *I* and *S* teologia.

THERMOS (θερμός), *heat:* thermometer, thermal, isotherm.

TITHĒMI (τίθημι), *I place:* thesis, hypothesis, antithesis, synthesis, theme, epithet, anathema, apothecary, hypothecate (THĒKĒ, θήκη = box).

TOPOS (τόπος), *place:* topic, topical, topographer.

TREPŌ (τρέπω), *I turn:* tropic, trophy. *I* and *S* trofeo.

ZAŌ (ζάω), *I live:* ZŌON (ζῶον), *animal:* zoology, zoo, zodiac.

LANGUAGES *concluded*

GAS MANUFACTURE

Illuminating and Fuel Gases. The Processes Followed and the Appliances Used in their Manufacture, Purification, and Distribution

WHEN Van Helmont, in the sixteenth century, invented the word *gas* he applied it to an occult principle which he supposed to pervade all matter. Modern chemistry applies the word to matter in an aeriform condition at ordinary temperatures. In a popular sense the word gas is used to describe the inflammable gaseous matter which is obtained by distilling coal, and it is better defined by adding words indicating the source as "coal-gas." The various gases have been dealt with in the section devoted to Chemistry, from which it has been gathered that many elements are in the gaseous condition. Illuminating and heating gas is a mixture of two or more elemental gases, such as hydrogen, nitrogen, oxygen, carbon monoxide, methane, and ethylene. Some gases are combustible, and are obviously of most use for illuminating and heating purposes, but certain non-combustible gases are unavoidably present as diluents which have no heating value.

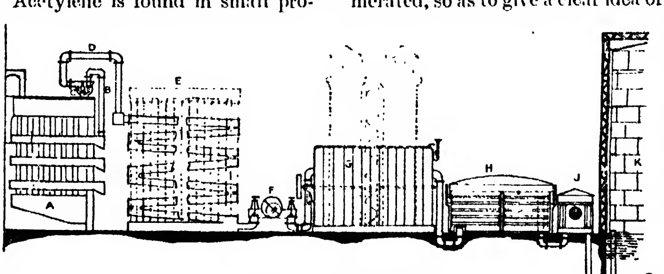
The chief gases which are present in either illuminating or heating gas are the following, which for convenience are divided into two classes.

Combustible Gases. The letters which follow the names are the chemical symbols. Hydrogen (H), carbon monoxide (CO), marsh gas (CH_4), ethylene (C_2H_4), acetylene (C_2H_2), benzene vapour (C_6H_6), naphthalene vapour ($C_{10}H_8$). The first two, hydrogen and carbon monoxide, are of the greatest importance, and occur in the largest proportions in gas. Marsh gas is also known as methyl hydride and methane, while mixed with air in explosive proportions it forms the dreaded *fire-damp* of the coal-miner. Although only marsh gas is here mentioned, it must be taken to be only the most important of what is known as the methane series of hydrocarbons, which always results when a body like coal is submitted to great heat. Marsh gas is not present in large quantities in coal-gas, but as it contributes to the luminous properties, it is of considerable importance. Natural gas, which will be referred to presently, is largely marsh gas. Ethylene, known also as olefiant gas, ethene, or heavy carburetted hydrogen is the most important of the ethylene series of hydrocarbons, which, like the methane series, consists of many gases of like chemical constitution. Acetylene is found in small proportions in coal-gas but larger quantities are made from calcium carbide, and so easily and cheaply, that this gas is burnt alone as an illuminating gas. The method of preparation will be separately dealt with. Benzene and naphthalene, it will be noticed, are referred to as *vapours*, because substances which are not gaseous at ordinary temperatures are not spoken of as gases. Benzene is a liquid and naphthalene a solid when isolated from gas, but they exist in gas in a dissolved state. They are important constituents, as they play a considerable part in the luminosity of gas. Naphthalene is apt to deposit from gas in very cold weather, and is the substance which chokes up the gaspipes in winter, causing much trouble by diminishing the supply.

Incombustible Gases. These, as has been explained, are diluents in gas, and are accidentally present, owing to the manner of preparation. The chief diluents are nitrogen, carbon dioxide, oxygen, and water vapour. Of these, nitrogen is present in the greatest proportion. It is an inert gas, and is the chief constituent of the atmosphere, but not the most important. Carbon dioxide is the gas used in aerating table waters. Most of this gas is taken out of coal-gas by a chemical process, but it is never entirely eliminated. Oxygen is known as a supporter of combustion—that is, gas needs oxygen (from the air) before it will burn. The oxygen found in coal-gas in small quantities comes from air that has obtained access at some stage of the process.

Luminosity. The greater part of the gases enumerated in the preceding paragraph on combustible gases do not give light when burnt. Hydrogen and carbon monoxide give only a blue flame when burnt, the luminous properties of gas being due to the hydrocarbons present—methane, ethylene, acetylene, benzene, and naphthalene. When the gas is required for heating purposes only it is not necessary to ensure the presence of hydrocarbons, and, as will be presently shown, the gases used for fuel purposes burn with a blue, non-luminous flame. In speaking of a blue flame, it should be noted that the non-luminous flame produced from coal-gas as burnt in domestic gas-ovens is due to the admixture of air near the burners. This results in the more nearly perfect combustion of the gas and loss of luminosity.

Various Kinds of Gases. Coal-gas, although the most familiar gas, is by no means the only gas used for illuminating and heating purposes. The chief kinds will now be briefly enumerated, so as to give a clear idea of what the various gases are, especially as some of the gases have several names. Each gas will be dealt with in its turn in succeeding parts of this article. *Coal-gas* is obtained by strongly heating coal in a closed fire-clay retort, but similarly *wood-gas* and *peat-*



1. SCHEME OF GAS MAKING

A. Furnace with retorts B. Ascension pipe C. Foul main D. Pipe leading to condenser E. Condensers (dotted lines showing vertical form) F. Exhauster G. Washer (dotted lines at back showing the tower form of washer) H. Purifier J. Station meter K. Gasholder

gas are made by heating wood and peat. *Natural gas* is found in various parts of the earth, and has merely to be collected and distributed through pipes to the house or factory. *Oil-gas* is made by decomposing petroleum or shale oil by heat, *oxy oil gas* being a variety obtained by mixing oil gas and oxygen. *Water gas* is made by passing steam over red-hot coke, the water vapour being split up into its elemental constituents. This gas is also known as *blue gas*. When mixed with hydrocarbon vapours, so as to make it burn with a luminous flame, water gas is known as *carburetted water gas*. Then there is the important class of gases known as *producer gas, generator gas, Siemens gas, Dowson gas, gaz pauvre (poor gas)*, or *mixed gas*. These being often a mixture of water gas and coal gas, as in the Dowson gas, are often referred to as *semi-water gas* or *steam enriched gas*. *Mond gas* is produced for fuel purposes by the combustion of small coal or slack, and the gases evolved from the blast furnaces or coke ovens of iron and steel foundries are known as *blast furnace gas* or *coke-oven gas*, according to the source.

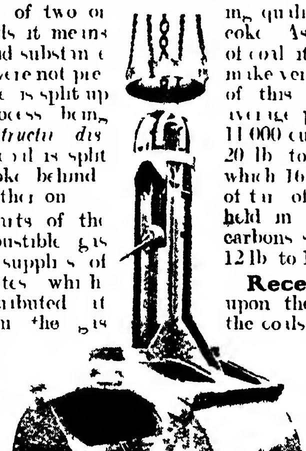
When producer gas is used in a suction producer—an apparatus making fuel gas for direct consumption in a gas engine—the term *suction gas* is sometimes used. *Methane hydrogen gas* is a gas made from steam and tar, being thus really a variety of carburetted water gas. *Air gas* or *gazolene gas* is simply air mixed with hydrocarbon vapour, the hydrocarbon used being gasolene or some similar light distillate of paraffin.

Distilling. As the word *distil* has been used and will be used again in this article, it is well that its meaning should be understood. Distilling, as applied, for instance, to the preparation of alcohol, implies that by means of heat one liquid is separated from a mixture of two or more liquids. In the case of solids it means the splitting up of a complex solid substance by heat into other matters which were not previously present. Coal, for instance, is split up or decomposed by heat, the process being more correctly referred to as *destructive distillation*. Roughly speaking, the coal is split up, giving off gas and leaving coke behind, but this will be fully explained further on.

Natural Gas. In many parts of the world Nature supplies a combustible gas ready made. There are large supplies of natural gas in the United States which, when collected, have been distributed at Pittsburg a hundred miles from the gas well at 5d. per 1,000 cubic ft. Unfortunately, the supplies of natural gas give out in time, with the consequence that industries which have flourished because of the supply of cheap natural gas have declined and caused ruin to towns in the United States which depended on the maintenance of manufacturing industries. A supply was discovered at Heathfield in Sussex, in 1897, by the London Brighton, and South Coast Railway Company, in searching for an underground water supply, and this has since been utilised for fuel and lighting purposes. Natural gas generally smells of paraffin, and consists chiefly of methane, with small quantities of other hydrocarbons, oxygen, hydrogen, and carbon monoxide. The proportion of methane in the Heathfield supply is less than is found in many natural gases from American sources, but the amount of higher hydrocarbons is greater, with the result that the English gas is more luminous.

Coal-gas. Coal is placed in long fireclay tubes known as *retorts*. The retorts are closed at both ends, but near one end there is a pipe through which the gaseous products are conveyed. The retorts are subjected to great heat by a furnace underneath, and give off crude gas. The gas is then cooled or condensed, when tar separates, the gas passing on to scrubbers or washers to be deprived of the last portions of tar and the ammonia which the gas contains. From the scrubbers the gas passes to purifiers to remove the remaining gaseous impurities, such as carbon dioxide, carbon bisulphide, sulphuretted hydrogen, and cyanogen, and is then placed in the gasholders from which it is distributed through the gas mains and pipes to the place where it is used. The process may be followed by referring to the diagram [1].

Varieties of Coal. The gasmaker recognises two kinds of coal—cannel, candle, or parrot coal and common or gas coal. Cannel coal gives a gas containing a large proportion of ethylene, the constituent which contributes most to the luminosity of the gas. Common or gas coal may be divided into caking and non-caking coal. Caking coal softens when heated and after the volatile constituents have been expelled yields a coke which is of cellular structure but which does not show the original shape of the coal. The non-caking coal retains the form of the coal in the coke and does not soften before giving up its gaseous constituents. Anthracite coal finds a special use in the production of fuel gas. It should be especially noted that not only does the gasmaker have to judge coal by the gas yield but he has to take into account the illuminating quality of the gas and the texture of the coke. As to the yield of products from a ton of coal it will be seen that it is not possible to make very definite statements. For the purpose of this paper it may be taken that the average products comprise 10,000 cubic ft. to 11,000 cubic ft. of gas, holding in suspension 20 lb. to 24 lb. of hydrocarbon vapours, of which 16 lb. to 18 lb. are benzene, and 120 lb. of tar, of which 25 lb. to 30 lb. are carbon held in suspension, 2 lb. to 3 lb. are hydrocarbons similar to the vapours in the gas, and 12 lb. to 14 lb. are naphthalene.



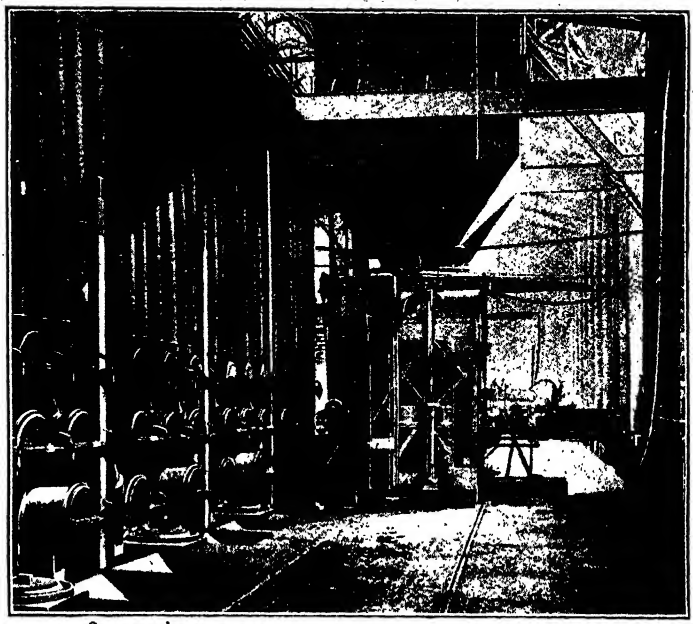
2. HONE'S PATENT GRAB
(Thames Ironworks Co. Ltd.)

Receiving the Coal. It depends upon the site of the gasworks as to how the coals are taken in. If the coal arrives by water it is, in modern works, taken from the ships or barges by self-acting grabs, such as Hone's patent grab [2], and delivered to elevating and conveying plant to the stores or retort houses. If the coal arrives by railway, mechanical appliances are employed for emptying the waggons, which, by means of an inclined railway, have been taken up to an elevated position. Where conveyors are used the larger lumps of coal will need breaking before being handled by the elevator buckets, there being two kinds of breakers—the roller and jaw types. If needed the coal can be automatically weighed at this stage.

Retort Houses. The plan of the building in which the coal is going to be distilled depends upon the particular system that is to be employed. The building is constructed of steel framework and

brick, the circular girder roof being largely adopted for double-bench retort houses. The working floor level is known as the *stage*, and below the level is the furnace and also the arrangements for conveying away the coke that comes from the retorts.

Retorts. Coal is distilled in fireclay retorts, which, in Great Britain, are machine made. The retorts are of two lengths, and are known as *singles* or *doubles*. The single retorts are from 8 ft. to 10 ft. long, and of D-shaped section, the height being 12 in. to 16 in. Double retorts are 20 ft. long, and are really two retorts set back to back, with a lid on each end. In the case of single retorts, one end only is fitted with a mouthpiece, the other end being built up. The end of the retort has fitted on it an iron socket to receive the lower end of the ascension pipe, or upright pipe which leads the gas from the retort, and a lid or mouthpiece. The type known as Morton's self-sealing mouthpiece is much used, but Candler's and Balfour's are varieties which more readily permit of the renewal of the wearing parts. The retorts are set in beds of from three to twelve, and are, from their position, known as bottoms, middles and tops. The collection of retorts, as seen in 3, is called a *bench*.



3. WEST'S COMBINED CHARGING AND DRAWING MACHINE
(West's Gas Improvement Co., Ltd.)

The Furnaces. These retorts are supported on fireclay walls 2ft. apart, which act as flues for the heat of the furnace. Originally, the retorts were heated direct by coke, but Sir William Siemens' regenerate furnace, or some similar type, is generally used at the present time. In this kind of furnace, highly-heated gas is made to impinge on the outer surface of the retorts, the heating value being increased in some types by the injection of steam, which forms a proportion of water-gas. This type of furnace will be referred to when we deal with producer-gas.

Charging and Drawing. Single retorts have a capacity of from $1\frac{1}{4}$ cwt. to 3 cwt. of coal, double retorts taking a correspondingly larger charge. The charging of the retorts is done by one of four methods: (1) hand shovelling; (2) the use of a long scoop; (3) by machinery; or (4) by gravity. The last-named method will be dealt with in our consideration of inclined retorts. By whichever of the three methods employed, the object in view is to spread the coal evenly on the floor of the retort. The shovel method is obviously the slowest, and necessitates much loss of heat. It is also terrible work for the stoker. When a scoop carrying the whole charge is employed, the time taken to charge a retort is under a minute. The scoop of coal is introduced into the retort and then turned over and withdrawn.

Charging Machinery. Much saving of labour results when machinery is employed for charging retorts, especially where power is used to drive the machines. West's manual charging machine is a simple type from which the well-known West's machines were evolved. The modern types of West's charging machines are driven by compressed air and run on rails on the stage in front of the retort bench. The retorts on one level are charged at the same time, after which the machine is adjusted for other levels. A scoop carrying the charge of coal is introduced into the retort, reversed, but each retort takes two scoopfuls. The first time the scoop enters the retort it turns over on the right, and the second time on the left side. The four levers for controlling the various actions of the machine are placed within easy reach of the stoker.

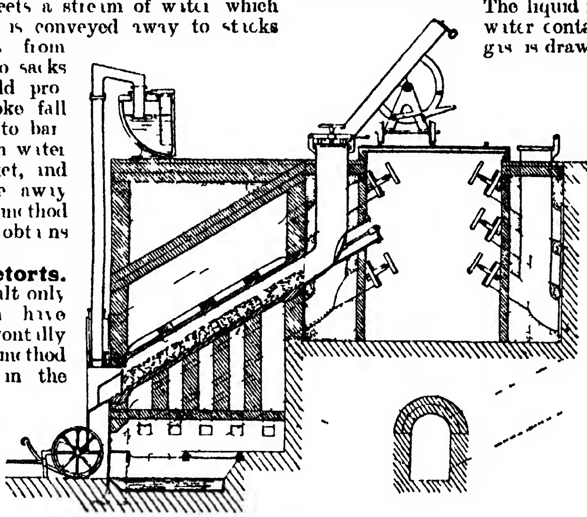
The Arrol-Foulis Machine. Another well-known type of charging machine is the one devised by Sir William Arrol and Mr. William Foulis. It is worked by hydraulic power at a pressure of 400 lb. per square inch. In this machine a hydraulic ram pushes charges of coal into the retort, five or six strokes being needed to charge a 10 ft. retort with $3\frac{1}{2}$ cwt. of coal.

Other Charging Machines. For small works the rapid charging machine of Messrs. Biggs, Wall & Co. is much used. There are two, one worked by manual labour and the other by power in the form of a small gas-engine. In Ruscoe's charging machine the charge is put into the retort in one operation by means of two scoops side by side, these being overturned in opposite directions. The newest types of charging machine, such as the De Brouwer and the turbine machine, are driven by electricity; in the latter machine the coal is shot into the retort by centrifugal force.

Drawing Machines. Sometimes combined in the same machine as the charging machine is a device for raking out the coke when it has been exhausted of its gas, or this may be a separate drawing machine [3]. The makers whose names have been mentioned in connection with charging machines also manufacture the drawing machines.

These consist essentially of a rake which is introduced into the retort and pulls out the glowing coke Water cooling devices are employed to cool the rake rod. The coke is allowed to fall down a space beneath the stage, being directed by means of an iron screen or *fender* placed in front of the drawing machine, and is taken away by *conveyors*, consisting of grids, or plates running on chains While on its journey the coke meets a stream of water which quenches it and it is conveyed away to stacks or storage hoppers from which it is filled into sacks or waggons The old process is to let the coke fall from the retort into barrows, quench it with water from a hose or bucket, and then wheel the coke away to the yard This method is costly, but still obtains in small gasworks

Inclined Retorts. So far, we have dealt only with retorts which have been placed horizontally in the setting This method is being replaced in the newer gasworks by an improvement which consists in setting the retorts at an angle [4] The method is due to André Coze, of Rheims, who patented the improvement in 1885 The retort are set at an angle of 29 to 34, and are fed at the uppermost end by travelling shoots thus saving time and expense of hand or machine stoking The coal storage tanks are placed above the level of the shoots leading to the retort, and by means of levers, measured quantities of coal are let fall into the retorts The lower end of the retort is fitted with the usual self sealing lid from which the ascension pipe rises When the coal enters the retort it is met at the lower end by a check plate against which it forms itself into a regular layer along the bottom of the retort When the distillation is finished the lids on the lower ends or drawing stage are opened and the coke falls out automatically or with slight assistance The latest development is to employ retorts set vertically, the claim being that a superior yield of gas and better quality of coke are obtained



4 INCLINED RETORTS

Effect of Temperature. The retorts are heated to a temperature of from 1 800 F to 2 000 F that being the end temperature four or six hours after charging the retort, when the coke is ready for drawing The effect of heating coal at the higher temperature is partly to decompose some of the tar and increase the quantity of ammonia in the crude gas The impurities, carbonic acid, cyanogen and the sulphur compounds are also increased Put in another way, this means that the higher temperature produces a larger yield of gas, but the illuminating effect of the gas is lower It takes from 15 tons to 20 tons of coke to distil 100 tons of coal, the lower amount being required in the regenerative furnaces, but as little as 10 tons of coke are needed in some of the modern generator furnaces

The Hydraulic Main. It will be remembered that each mouthpiece of the retorts is fitted with an ascension pipe, an upright pipe which conveys the gas from the retort to what is called the *hydraulic main.* The ascension pipes are about 5 in in diameter, and rise some distance above the retort bench; they join a descending pipe by means of a short bridge of horizontal pipe, the dip pipe leading to the hydraulic main This pipe dips about 1 in below the water in the main The hydraulic main is usually square, or with a rounded bottom, and is built up in sections The liquid it contains is tar and water containing ammonia. The gas is drawn through this main by pumping engines or exhausters [5], to be referred to presently The purpose of the liquid is to condense much of the tar and like matters carried over by the hot gas, and prevent the gas returning to the retort when it is opened for charging All the retorts in one retort house are connected with the same hydraulic main The pipe which conducts the gas and liquid from the hydraulic main is known as the *foul main* This is connected with the *tar well* the tar and aqueous part separating in time while the gas goes on to a series of cooling pipes known as the *condenser*

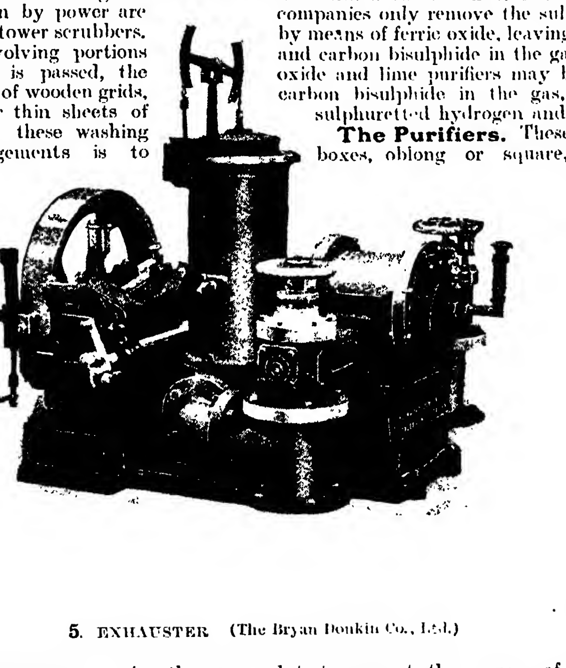
Composition of Crude Gas. This is a convenient place to refer to the composition of the crude gas as it comes from the retorts The combustible gases contained in the crude gas are hydrogen (42 per cent to 53 per cent), methane (32 per cent to 39 per cent) carbon monoxide (3 per cent to 10 per cent) gaseous hydrocarbon (2 5 per cent to 4 5 per cent) The impurities which it is desirable to remove as far as possible are small percentages of carbon dioxide nitrogen sulphuretted hydrogen ammonia cyanogen and carbon bisulphide The nitrogen is not removed by any of the subsequent purification processes

The Condenser The gas, after it leaves the hydraulic main passes through a series of vertical or horizontal cast iron pipes so arranged that the gas has to traverse the whole length of the pipe During its passage in this condensing apparatus the gas is cooled and reduced in volume, and there is separated more tar and aqueous matter, which is led off to the tar well before referred to by syphon arrangement Climatic conditions in England render air cooled condensers efficient although in hot weather it is necessary to spray the outside of the tubes with water The condensing pipes are from 6 in to 12 in in diameter, and there are from nine to twelve rows of pipes placed above each other (in the modern horizontal condensers) Other kinds of condensers are cooled by water the principle being that the gas passes up a tower within which are vertical pipes with water circulating therein. Clapham's "Eclipse" condenser has sometimes as much as a mile and a half of tube in one condenser.

The Exhauster. The gas passes from the condenser to the exhausters [5]. These are cylindrical pumps, the purpose of which is to draw the crude gas away from the retorts, and, when the gas has passed through the exhausters, to force it onwards through the washing and purifying apparatus. The exhausters generally used are Beale's, invented in 1848, and improved in 1866 and 1871. Since then E. B. Donkin has patented a further advance in this type of rotary exhauster by which the internal drum is made to do duty as a piston. The exhausters are driven by a steam-engine, the rate being carefully regulated so as to maintain the vacuum in the hydraulic main at a constant pressure.

Scrubbers and Washers. From the exhausters the gas passes to the scrubbers or washers, where it is deprived of its ammonia and a part of the carbonic dioxide, sulphuretted hydrogen, and cyanogen. There are different types of scrubbers, the principle of all being that the gas is finely broken up and brought into contact with a stream of water passing the opposite way to the gas. The tower form of scrubber consists of a tall tower filled with coke or wooden grids, a stream of water falling from the top of the tower through the coke. The gas enters at the bottom, and has to make its way up through the wet coke, losing on its way the ammonia it contains. The towers are run in series, the first one containing gas liquor, and the last one clean water. As the liquors become saturated they are passed to a plant for recovering the ammonia. Washer scrubbers driven by power are now replacing the older tower scrubbers. These have central revolving portions through which the gas is passed, the interior consisting either of wooden grids, brushes, wooden balls, or thin sheets of metal. The aim in all these washing and scrubbing arrangements is to saturate the liquors fully, using as little water as possible, because it is a needless expense to have to recover ammonia from weak solutions.

Tar Extractors. Means are adopted at various stages of the process of condensing and washing to lead off the tar, but a miniature scrubbing apparatus placed before the scrubbers proper, with the idea of preventing clogging of the scrubber, is known as a *tar-extractor*.



5. EXHAUSTER (The Bryan Donkin Co., Ltd.)

Chemical Purification. As the gas leaves the scrubbers it still contains sulphuretted hydrogen (1 per cent. to 2 per cent.), carbonic acid (1 per cent. to 3 per cent.), and small quantities of carbon bisulphide, and other sulphur compounds. The removal of these impurities is a chemical process.

It is provided by the Gasworks Clauses Act of 1847, that gas shall not give evidence of the presence of sulphuretted hydrogen when tested with lead-paper. This and other sulphur compounds are objectionable in gas, because the products of combustion which they yield (sulphur dioxide) are of an injurious character, both when breathed and because of their action on the contents of a room. Carbon dioxide diminishes the luminosity of the gas, and, as has been explained earlier in this article, it is not a combustible gas. The obligations of the various gas companies in regard to the removal of impurities are not identical. In some cases the carbon dioxide need not be removed, but as it diminishes the luminosity of the gas it is to the gas company's interests to see that it is removed entirely or diminished very considerably.

Scheme of Purification. To remove carbon dioxide the gas is passed over lime, the sulphuretted hydrogen is removed by ferric oxide or Weldon mud, and the carbon bisulphide by sulphided lime. The order of removal differs, as also does the number of purifiers which are devoted to chemical purification. This, as has been explained, is because of the differences in the legal requirements of the gas undertakings. If a complete scheme be adopted, it will require eight purifiers, the first two being lime vessels, the next two ferric oxide containers, two more for sulphided lime, and the last two in the nature of check vessels (often containing Weldon mud), to remove the last traces of sulphuretted hydrogen. Another scheme, known as the *all-lime* system, requires four purifiers containing lime and a check-box of ferric oxide. Other gas companies only remove the sulphuretted hydrogen by means of ferric oxide, leaving the carbon dioxide and carbon bisulphide in the gas, and, again, ferric oxide and lime purifiers may be used, leaving the carbon bisulphide in the gas, but removing the sulphuretted hydrogen and carbon dioxide.

The Purifiers. These are large cast-iron boxes, oblong or square, each vessel being from 30 ft. to 40 ft. square. Inside, a series of wooden grids is arranged, and carries the purifying material. These shelves are arranged so that the gas passes over as much of the purifier as possible—that is, the journey taken by the gas from its entrance to its exit is as long as possible. The lid of the purifier has a flange, which dips into a channel or U-section round the top of the purifier containing water, thus acting as a seal or lute to prevent the escape of the gas. Dry seal covers are used in modern works. The lid is brought into contact with strips of indiarubber, and fastened down with swing bolts. The number of tiers of grids varies according to the material and depth of the purifier: the latter is generally 5 ft. The set of purifiers is arranged with valves and exit pipes so that the order of the purifiers can be changed or put out of action to permit of recharging. It is usual to have more purifiers than are

required for use, so that the process is efficiently carried out. When it is found that a purifier is not working properly, it is put out of action and a fresh purifier is used in its place.

Lime Purifiers. Lime, when freshly slaked, is one of the best substances known for absorbing carbon dioxide, the substance formed being a carbonate. The lime purifiers have generally four tiers of grids, upon which the lime is placed about 4 in. deep. The lime is carried alongside the purifier in wheelbarrows, and arranged by a workman with a shovel. The removal is effected by means of an outlet provided at the bottom, or the spent lime is shovelled into sacks and lifted out. The lime, as it is obtained from the earth, is burnt and slaked by watering it. A cubic yard of good burnt lime requires about 135 gal. of water to slake it, yielding 2¼ yd. of slaked lime. It takes 5·7 cubic yd. of slaked lime to purify 1,000,000 cubic ft. of gas from carbon dioxide, this being the quantity needed in practice; in theory, it is less. In addition to taking out the carbon dioxide the lime also takes out a portion of the sulphur (8 gr. to 10 gr. from 100 cubic ft. of gas), as carbon bisulphide, as well as some of the sulphuretted hydrogen and cyanogen.

Oxide Purifiers. The purifiers which serve for the removal of sulphuretted hydrogen are filled either with hydrated ferric oxide or a mixture of the oxide and Weldon mud (chiefly manganese dioxide). The ferric oxide that is used is natural bog ore (known also as *iron sponge*, or *iron mass*), which occurs in extensive deposits in the North of Ireland and Holland. This bog ore contains about 30 per cent. of ferric oxide, the rest of the substance being moisture and vegetable fibre, both of which are useful in dividing it, so that the sulphuretted hydrogen has a better chance of being absorbed. About 6 yd. of bog ore will be needed in practice to purify 1,000,000 cubic ft. of gas from sulphuretted hydrogen. The bog ore, which is reddish-brown, turns black when it has absorbed sulphuretted hydrogen, the ferric oxide being converted into ferric sulphide.

Revivification. The ferric sulphide which is obtained by passing sulphuretted hydrogen over ferric oxide is a very unstable body. It has the curious property, when exposed to the air, of absorbing oxygen and returning to its original state as ferric oxide, the sulphide being left as free sulphur, mixed with the ferric oxide. This property is made use of for restoring the ferric oxide to efficiency when it has become saturated with sulphuretted hydrogen, the process being known as *revivification*. The material can be revivified as many as fourteen times, after which the free sulphur it contains (about 50 per cent.) so dilutes the compound as to render it useless. This sulphur is either recovered at the gasworks or the sulphur-laden oxide is sold to makers of sulphuric acid. The revivification is attended by changes of colour which enable the workman to tell how the change is progressing. Sometimes the absorption of oxygen is so rapid that the mass takes fire, so it has to be carefully watched, and not spread out in layers of less than 12 in. deep. The oxide is taken out of the purifiers for revivification, and spread on a concrete floor, being turned over every few days until the oxidation is complete. A process of revivification in the purifiers is practised at some works, gas mixed with air or oxygen being passed through. This obviously saves a lot of handling of the oxide, but is not so easily managed, and the ferric oxide in the purifier has a tendency to become caked when it does not readily absorb sulphuretted hydrogen.

Weldon Mud. The use of Weldon mud in place of bog ore was proposed by Messrs. Hood and Salamon in 1888. Weldon mud is a by-product in the manufacture of chlorine, and a nuisance to the alkali-maker. Hood and Salamon, by a process of decantation, washed out most of the calcic chloride contained in the mud, leaving a mixture of hydrated oxides of lime and manganese. The mass is allowed to dry until it is in a moist, crumbly condition, when it is ready for use in the purifier. The manganese oxide becomes manganese sulphide by the absorption of sulphuretted hydrogen, changing its colour from yellowish-brown to pink. When saturated with sulphuretted hydrogen, the Weldon mud is revivified in like manner to bog ore. It is claimed to be superior to bog ore, because of the greater activity of Weldon mud.

Carbon Bisulphide. There still remains a very objectionable impurity in the gas—carbon bisulphide. The process of removal is to pass the gas over lime that has been saturated with sulphuretted hydrogen. This is prepared by passing gas free from carbon dioxide, but still containing sulphuretted hydrogen, through a lime purifier, forming sulphides of lime. This acts upon the carbon bisulphide in the gas, and forms probably calcium thiocarbonate. Before passing the gas through the sulphide purifiers it contained from 30 gr. to 40 gr. of carbon bisulphide per 100 cubic ft. of gas, but this is reduced by passage through the purifiers to as low as 6 gr. of sulphur compounds. In London the maximum of sulphur that is allowed in the gas is from 17 gr. to 22 gr. per 100 cubic ft., according to the season. As a matter of fact, the quantity present is much below the maximum—some 10 gr. to 12 gr. A purifier of about 28 ft. by 36 ft., charged with six 10-in. tiers of lime, will take up about 5 tons of sulphuretted hydrogen, and will absorb, when in action, at least 3 tons of carbon bisulphide. Two such vessels should suffice for a year's working on a daily output of about 3,000,000 cubic ft. of gas.

Cyanogen. The cyanogen compounds which are present in the gas, chiefly combined with ammonia, are taken out by several stages of the purification processes. The water in the scrubbers absorbs some, the lime another portion, and the ferric oxide the remainder. When absorbed by lime, it is difficult to recover the cyanogen in a paying form, but it is easier to obtain it when it has been absorbed by ferric oxide. For this reason, when cyanogen recovery is practised, lime purifiers must not be placed before oxide purifiers. Special processes are being worked for the recovery of cyanogen compounds, these latter being absorbed by certain reagents, such as ferrous sulphate, contained in a vessel placed in front of the scrubbers.

Candle-power. The quality of gas supplied by gas companies is judged by its illuminating power. This is fixed in London as 16-candle power—that is, one light from gas consumed at the rate of 5 cubic ft. per hour shall be equal in intensity to one light produced by sixteen standard sperm candles. These candles are defined by the Metropolis Gas Act, 1860, as being six to the pound, and burning 120 grains of spermaceti per hour. The gas is burned in a standard burner known as the London Argand No 1, and the light judged by a Bunsen photometer. The gas supply of London is subjected to frequent periodical examination as regards illuminating power, there being twenty testing stations in charge of the London County Council. In 1902 the sperm candles were replaced by a new standard lamp designed by Mr. Vernon

Harcourt, in which pentane (a petroleum distillate) is burnt. Every detail of the lamp is standardised, so that a light of the same intensity is always obtainable, the light being equivalent to the standard candle previously employed. Very precise directions are issued in a publication entitled "Notification of the Gas Referees," which is obtainable from the Government stationers. When gas was made from cannel coal there was no difficulty in supplying coal showing 27-candle power; such gas was used in the Government offices up to about 1876. There was a lower power gas supplied, made from bituminous coal, which tested at 16-candle power, that being the statutory illuminating power at present. As gas is more used for heating, and with mantles, and as it is easier and cheaper to make gas of a lower candle-power, there is a movement on foot among gas companies to obtain consent to supply 14-candle power gas.

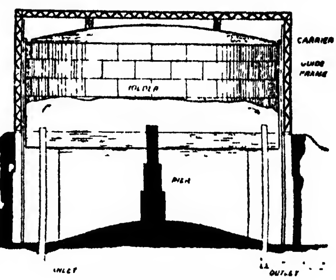
Gas Enrichment. To bring the illuminating power of gas up to standard, it was formerly the practice to employ a certain proportion of cannel gas. The increasing dearness of cannel has led to the devising of other means of enriching gas. The cheapest enricher is benzene, which is volatilised in a special apparatus; toluene, xylene, and naphthalene are better enrichers, but they are not so volatile. The albo-carbon method of increasing the illuminating power of gas at the burner involves the use of naphthalene, which is vapourised by the heat of the gas that is burning. As it is now usual to mix water-gas with coal-gas, the former is carburetted—that is, enriched with benzene or carburine before being added to the coal-gas, and is made the means of adjusting the candle power to standard in the finished gas as supplied to the public. This matter will be referred to again when we consider water-gas.

Gas Testing. To test for *sulphuretted hydrogen*, a strip of lead acetate paper is exposed to the action of a stream of gas for three minutes, when any discoloration that results is evidence of the presence of sulphuretted hydrogen. The lead acetate paper is made by wetting white filter paper with a solution of 60 grains of lead acetate in 1 oz. of water. *Ammonia* is tested for by passing 10 cubic ft. of the gas over glass beads moistened with a known quantity of sulphuric acid of known strength. Any loss of acidity due to the action of the ammonia is tested by another solution of ammonia of known strength. If a complete analysis of the gas is to be made it is conducted in the following order. (1) *Carbon dioxide* and sulphuretted hydrogen, by shaking with caustic soda solution; (2) *oxygen*, by an alkaline solution of pyrogallol; (3) unsaturated *hydrocarbons*, by absorption with a solution of bromine in potassium bromide; (4) *carbon monoxide*, by an acid solution of cuprous chloride; (5) *saturated hydrocarbons*, by partial absorption by paraffin oil, and exploding and analysing the resulting carbon dioxide; (6) *nitrogen*, by mixing a fresh volume of the gas with oxygen, exploding and removing the carbon dioxide and excess of oxygen, when the residue is nitrogen; (7) *hydrogen*, by difference.

By-products. The coke which is yielded from the distillation of coal is employed as a heating agent for the furnace or generator yielding the heat by which the distillation is effected. There is, however, a large excess which is sold as a fuel. If the use of coke as a fuel were more general the smoke problems in large towns would be solved; special grates, however, are required for burning coke effectually. From the gas liquor ammonium sulphate is obtained; it is used as a manure, but large quantities of pure anhydrous ammonia are now required for use in refrigerators. Cyanogen is recovered from the spent oxide of the purifiers. The tar which collects in the tar-well is distilled, and yields a great variety of liquids, which are the starting-point of many aniline dyes and synthetic medicines. Bricks are made from the clinker, and spent lime of the lime from the purifiers; it will be remembered also that iron oxide saturated with sulphur is used for making sulphuric acid. Tar is also used as a paint for outside fences, and when cheap it is economical as a fuel or for enriching gas, as in the Dinsmore process.

Station Meters. When gas leaves the purifiers it is measured by large *station meters*. Gas is measured like any liquid, by alternately filling and emptying an enclosed space of known capacity. The capacity of the space multiplied by the sum of the fillings and emptyings is the volume measured, which is transmitted to a dial. Upon the accuracy or otherwise of the meter depends the record of the yield of gas from the coal employed. The station meter is of the variety known as a *wet meter*, and is of exactly the same construction as the meter supplied for domestic use, but capable of registering very large quantities of gas.

The Gasholder. The gas is finally passed into the large gasholders [6], or gasometers, as they are often incorrectly called. The gasholder is a hollow vessel inverted in a tank of water and maintained in equilibrium by an outer framework or cables.



8. GASHOLDER

The concrete base upon which the gasholder rests is best made of a mixture of old retorts and Portland cement, and the inner surface of the excavation or tank is coated with cement concrete. The gasholder is made of plates of iron riveted together. The different storeys of the gasholder are known as lifts, and slide or telescope within each other, being made gas-tight by water-seals. Gasholders are now made of enormous size, as the larger the holder the cheaper the storage cost. The largest gasholder in the world is at East Greenwich. This is a six-lift holder, and has a capacity of over 12,000,000 cubic ft. of gas. It costs approximately £5 per 1,000 ft. of storage. Spiral gasholders have lifts which ascend and descend with a spiral action. Gasholders equal to at least a day's maximum supply must be provided.

Gas-governor. The gas is now ready for delivery to the public, but, as the demands vary with the time of day and season of the year, an arrangement known as a *pressure governor* is employed to maintain constant pressure on the main. The regulator acts automatically, and is constructed on the principle of a gasholder, in that the rising and falling of a miniature gasholder opens or shuts a throttle valve admitting gas to the main. In large works an exhauster is also required to send the gas through the mains, but in many cases the down pressure of the gasholder is the force which drives the gas through the distributing mains.

Wood-gas. Murdock, to whom we owe the introduction of coal-gas into everyday use, told the Royal Society in 1808 that he had also experimented with wood and peat as a source of gas. The gas which is given off on destructively distilling wood is of good illuminating power if care is taken to employ sufficient heat to decompose the liquid oils which distil over. At high temperatures these yield gaseous hydrocarbons, which contribute in a great measure to the illuminating power. The process of manufacturing wood-gas is practised only in those countries where wood is plentiful and coal expensive. Riche's gas plant is used, the retorts being of cast iron. The gas consists of hydrogen, carbon monoxide with marsh-gas and ethylene, the carbon monoxide being in larger proportion than in coal-gas, some of it being due to the decomposition of the water which is contained in all wood. Sawdust and cork are sometimes distilled for gas, and several methods have been proposed for the preparation of peat-gas. These gases can be carburetted to increase their illuminating powers.

Air-gas. What is known as *air-gas* consists of air carburetted with the vapours of highly volatile hydrocarbons, such as gasoline, carburine, and benzene. The hydrocarbon needs to be very volatile, and of constant and uniform composition. Some small installations in places where gas is not available, and acetylene too expensive, have been successful. At Llanberis School a plant has been satisfactorily working for some time. It consists essentially of three parts: (1) A large, shallow cylindrical copper tank holding 250 gallons, buried some 30 ft. or more from the building, and filled with gasoline through a pipe and closed airtight by a screw tap. Two other pipes, an inlet and outlet, are fitted into the top of the tank, and pass underground to the cellar of the building. (2) In the cellar a pump, worked by a weight on pulleys, forces air through the inlet pipe on to the surface of the gasoline in the tank. Evaporation is rapid—gasoline boiling at from 35° C. to 70° C.—and the mixture of vapour and air is driven through the outlet pipe into (3) an automatic mixer, by which a definite and known quantity of air can be added, so that the proper proportion for burning may be constantly maintained. The apparatus is simple, and requires very little attention. The weight has to be wound up once a week, and the mixer adjusted by moving a small wheel along a rod, about once every two or three months, and the tank filled about every twelve or eighteen months. The frequency of the recurrence of these operations depends on the size of the plant relative to the demands upon it. Some of the air-gas plants require heat to evaporate the hydrocarbon, this increasing in a measure the risks of explosion.

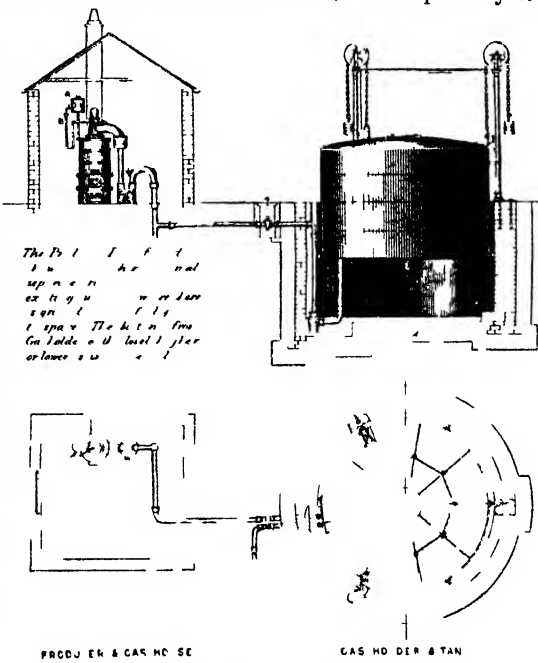
Ether-gas. A similar air-gas can be made with ether, but in this case the air is passed through a box containing a fibrous substance which has been saturated with ether. On dilution with air, ether loses its luminous flame; but any desired degree of luminosity can be imparted by carburetting with benzene. The cost of ether air-gas enriched with benzene is about twice that of oil-gas, its chief advantage being the ease with which a small plant can be installed to meet any temporary requirement. In the ether saturators sometimes employed in optical lanterns oxygen is passed through a metal box filled with ether-saturated cotton-wool.

Oil-gas. When oil is subjected to destructive distillation it is broken up—"cracked" is the technical term—and a gas possessing high luminosity and heating power is obtained. The earliest process was invented by John Taylor in 1815, and shortly afterwards a method of compressing the gas was devised so that it could be readily transported. On account of the last-named fact, the gas was also known as *portable gas*. To chemists this early manufacture possesses an unusual interest, as it was from the liquid condensed in the cylinders of portable gas that Faraday first prepared benzene, this discovery laying the foundation of the aniline colour industry, which has now attained so much importance. The use of oil-gas, however, almost died out on account of the competition of the cheaper coal-gas, and it was not till 1870 that oil-gas was revived as a specially convenient method of illuminating railway carriages, buoys, and lightships.

Pintsch's Apparatus. There are several processes of manufacture. The Pintsch system is one in use by many railway companies, the following being a description of the process as used by the Great Northern Railway at Holloway. The plant was designed to make 60,000 cubic ft. of gas per day. The 10 in. D-retorts in which the oil is cracked are made of 1 in. metal, and are 6 ft. in length; they are worked in pairs, and are kept as nearly as possible at a cherry-red heat. Each pair will make from 300 cubic ft. to 400 cubic ft. of gas per hour, and 600,000 cubic ft. to 700,000 cubic ft. of gas before they require renewal. Immediately before the gas enters the hydraulic main a ¾ in. iron pipe, provided with a stop-cock, is tapped in so that the colour of the gas may be seen, this being the practical test applied to ascertain the quality of the gas, and whether the proper quantity of oil is being admitted. Another test for regulating the supply of oil is to drop a small quantity of the tar from the gas main upon a sheet of white paper; if too much oil is being admitted to the retort, a greasy ring will be found round the spot of tar; but if the right quantity is being used, no greasy ring will appear. The furnaces consume 160 lb. to 180 lb. of coke for every 1,000 cubic ft. of gas produced. The oil used is a once-refined shale oil: it runs to the retorts from a galvanised iron cistern of 50 gallons capacity through a 1 in. iron pipe, at the end of which is fixed a gun-metal micrometer cock for regulating the supply. From this supply pipe the oil flows into a small funnel attached to a ¾ in. syphon pipe, 12 in. deep, connected with the retort; it then falls on a loose tray, preferably of steel, and is instantly converted into a dense brown vapour. The gas issuing from the retorts passes to the hydraulic main, then through air condensers, washers and purifiers into the meters and gasholders. The purifiers contain a mixture of two parts of slaked lime to one part of sawdust placed on wicker trays, and are recharged every week. The cylindrical steel storeholders are 17 ft. 6 in. in length, and 4 ft. 3 in. in diameter: they are tested by hydraulic power to 300 lb. per square inch, and are provided with a pressure gauge registering up to 200 lb. per square inch. The gas is forced into the storeholders through a 1 in. extra strong lead pipe by compressing engines. Each holder is provided with a cock at the bottom for drawing off the condensed hydrocarbon, of which about a gallon is obtained from every 1,000 cubic ft. of compressed gas. Each gallon of oil yields 80 cubic ft. to 85 cubic ft. of gas. The oil is run in at about 12 gallons per hour. Other systems are the Keith, Pope, and

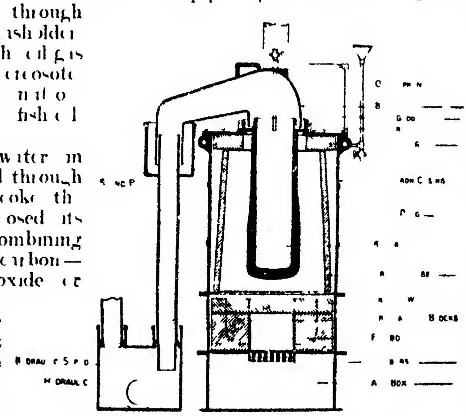
Peebles processes. The object aimed at in the last-named—Young, of Peebles—is to produce an oil gas specially adapted for carburetting water gas and enriching coal gas.

Mansfield's Apparatus. A form of oil gas plant much used for private installations is that made by Mansfield & Sons, Ltd., Liverpool. The illustration [7] shows a sectional elevation of the complete plant, the details of the gas producer being shown in the smaller figure [8]. The producer has a retort suspended in a cast iron casing, lined with fireclay fittings. The top of the retort is made gas tight by a lead joint. When the retort is hot enough to make gas the lead melts, the bonnet sinks into it, thus making an automatic joint. The retort is heated by a coal or wood fire, and a strong red heat as seen through a sight plug is maintained throughout the gas making process. Oil is stored in a suitable tank in any part of the building. From this tank a pipe is led to the oil syphon of the producer. A small cock attached to the end of the pipe regulates the flow of oil which is permitted to run in a fine stream into the funnel of the oil syphon. Through this it passes into the retort, and is converted into gas. The gas rises into the bonnet and passes down the standpipe into the hydraulic main through which it passes into the gasholder. The materials from which oil gas can be made include creosote, palm oil, castor oil, cocoanut oil, Rangoon oil, kerosene, fish oil, tallow, and unrefined fat.



7. MANSFIELD'S OIL GAS PLANT

Water-gas. When water in the form of steam is passed through a mass of incandescent coke the water molecule is decomposed, its constituent elements combining with the coke—a form of carbon—to make carbon monoxide or carbon dioxide and hydrogen. If the temperature of the coke is about 500° C., carbon dioxide and hydrogen are formed, but at 1,000° C. the products are carbon monoxide and hydrogen. The mixture of gases thus obtained is known as *water gas*. In discussing the various combustible and non-combustible constituents of gas, it was pointed out that carbon monoxide is combustible, but that carbon dioxide is non-combustible, and thus of no value as an illuminating or heating gas. The object will be, therefore, to produce carbon monoxide in preference to carbon dioxide if the usual properties of a gas are desired. There are, however, cases in which the carbon dioxide is preferable, as will presently be explained. The reaction in making water-gas takes place in two stages—the first, in which the water molecule is decomposed, absorbs heat in course of the change, and the second, when the carbon monoxide is being formed, is a reaction where heat is given out. The process is on this account an intermittent one. Air is blown in a blast over glowing coke till the mass becomes intensely hot, the gas being given off at this stage being known as *producer* or *generator gas*. When the coke is hot, steam is blown in in place of the air, water gas being produced. The reaction rapidly cools the coke, so that it becomes necessary to stop the injection of steam and again blow the coke to incandescence by turning on the air blast. The producer or generator gas is passed into a second vessel filled with firebricks, which it raises to a white heat, and it is into this second vessel or *superheater* that the steam is passed before it goes into the fuel in the generator. Thus water-gas is made for about four minutes and the heating up occupies about ten minutes. This question of producer gas will be dealt with later.



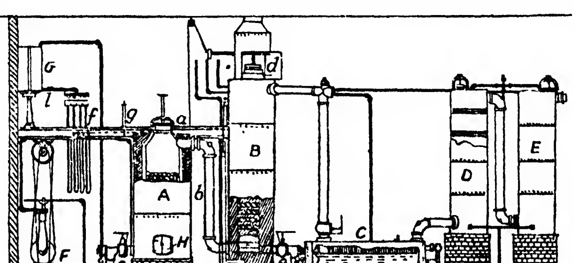
8. DETAILS OF THE GAS PRODUCER

Carburetted Water-gas. It will be remembered that both hydrogen and carbon monoxide give *blue* or non-luminous flames, and to make the gas give a luminous flame it is *carburetted* in a way similar to the enriching process referred to in the article on coal-gas. This carburetting is effected by the hot process in an additional chamber, in which oil is decomposed and the vapours mixed with the water gas in a manner which will be best understood by reference to our remarks on oil gas. The enriching may also be carried out in the cold process by allowing the gas to pass into a vessel containing carburine, a mixture of gasoline and benzene, which vessel is surrounded by hot water

to promote evaporation. This, again, will be readily grasped when the section of this article on air-gas is read. Carburetted water-gas is much used in the United States, where gas-coal is comparatively dear, and hence cannot advantageously be used for preparing coal-gas. In this country the large gas companies are in the habit of mixing about 10 per cent. of carburetted water-gas with the coal-gas as a convenient method of raising the candle-power of the latter to the standard candle-power. Water-gas is more poisonous than coal-gas, as it consists mainly of carbon monoxide and hydrogen, the former a very poisonous gas. Moreover, as water-gas is inodorous, it is not so easy to detect leakage. This objection can be got over by giving the gas a strong smell by passing over naphthalene or impregnating with isocyanides or organic sulphides. The objection does not arise in cases where the carburetted water-gas is mixed with coal-gas, but the poisonous properties of carbon monoxide is a reason why the proportion of water-gas should not be unduly increased. If it were not that the public want a gas to give a luminous flame always it could very well be made luminous at the burner by means of an incandescent mantle.

Advantages of Carburetted Water-gas. After referring to the disadvantages of water-gas, it is only just to state the advantages. These are that the gas can be made of high illuminating power; economy in wages, since fewer workers are required than for the manufacture of coal-gas; the small cost of the installation; small area occupied by the plant; the utilisation of coke; freedom of the gas from ammonia and small amount of sulphur compounds to be removed. There is no need to remove the small amount of carbon dioxide, and the apparatus can be got ready for working in less than four hours, which is a convenience in case of a suddenly increased demand for gas. In coal-gas works it is economical to use the red-hot coke as it is drawn from the retorts.

Lowe's Water-gas Process. Having stated the chief points in the manufacture of water-gas, a few details of some of the processes actually employed may be given. In the Tessié du Motay process the water-gas is made from anthracite (in place of coke) and steam, then purified by passing through a lime-box, and finally carburetted by the cold process, the resulting mixture of water-gas and naphtha, or carburine vapour, being led through specially arranged retorts to ensure decomposition of the hydrocarbon, and finally stored. Lowe's process will be best understood by reference to 9. In this the decomposition of the naphtha is carried out simultaneously with the production of the water-gas—that is, it is carburetted by the hot process. A is the generator, filled with anthracite through the manhole *a*. A fan, F, sends a current of air into the generator through the valve *c*; the gases escaping through the pipe *b* into the superheater B, filled with stacked firebricks; when the gases contain enough carbon monoxide to burn, air is also blown in at the base of the superheater through the valve *e*, the products of combustion escaping into the open at the top through *d*. When the requisite temperature is attained, *c*, *d*, and *e* are closed, and the fan nearly stopped, a very gentle current being still maintained through small orifices in *c* and *e*, purposely arranged to prevent back-rush of water-gas into the air main, which otherwise might cause an explosion. Steam is then turned on at the base of the generator, and a stream of naphtha at the top supplied from the tank by means of a series of distributing tubes. The mixture of hydrogen, carbon monoxide, and a little carbon dioxide formed in the generator, vaporises the naphtha, and the mixed gases act on one another in the superheater, ultimately producing an illuminating gas of high quality, when the steam and naphtha supplies are properly proportioned. The gas is washed in the purifier C, and the two towers, D and E, and stored. The steaming operation is continued for twenty minutes, when the steam is shut off, more anthracite filled in through the manhole, and the cycle of operations begun again. Every few hours (six to twelve) the doors, H, at the base of the generator are opened and the anthracite residue raked out. As will be seen, the product is a mixture of oil and water-gases. All sorts of variations of this process are in use. In one the superheater is filled with lumps of lime to free the gas from carbon dioxide. The Granger plant is arranged so that the naphtha is forced in under pressure, thus facilitating its gasification, and in the Hanlon and Leadley process bituminous coal is used in place of anthracite. Humphrey's apparatus consists of two generators, two carburettors, and two superheaters. The generators are connected by means of a flue, and each of them is also in connection with a carburettor and a superheater, the object being to enable the process to be alternately worked from the left and right.



9. LOWE'S WATER-GAS PLANT

The Dellwik-Fleischer System. In the water-gas processes just described, the fuel is raised to incandescence by blowing air through so deep a bed of fuel that the chief products are carbon monoxide and nitrogen (from the air). One pound of carbon develops only 2,400 heat-units when burnt to carbon monoxide, but 8,080 when burnt to carbon dioxide, for the reason explained in the opening remarks about the water-gas reaction. Carl Dellwik has devised a process by which the products of the "blow" are carbon dioxide and nitrogen, and thus the additional heat-units are made available in raising the temperature of the bed of fuel in place of passing into the producer gas. The result is that twice as much water-gas is obtained, the extra heat reduces the "blow" period, and allows the "run" (steam admission period) to be prolonged. The flow of steam to the fuel is regulated so that even at the end of the run there is no excess of steam to oxidise the carbon monoxide to dioxide. A ton of good coke yields 70,000 cubic ft. of water-gas in place of 34,400 by the older process. Under the older processes the cost of 1,000 cubic ft. of water-gas is from 4d.

to 6d.; by a large Dellwik-Fleischer installation the cost is below 3d. The gas produced by the Dellwik process has been successfully utilised at Cleethorpes for mixing with coal-gas by passing it into the retorts during carbonisation Dr Fleischer improved the original Dellwik process, hence his name becomes to be associated

Methane Hydrogen Gas. This is the name of a process which has been successfully adopted at Sligo and Truro The generator is filled with coke, and then blown up to incandescence, the waste gas escaping part of the way up the generator to the stack pipe, so that the fuel above is dried and heated before it comes down into the hot zone and also serves to filter out the finely divided carbon produced during the run When the requisite temperature has been attained the valves are altered, and steam and tar are injected into the body of incandescent fuel The tar is decomposed into carbon and gaseous products—containing methane—the steam combining with the coke and separated carbon to produce water gas A further quantity of steam injected at the bottom of the generator serves to produce ordinary water gas, which passes away and mixes with the other gases This gas is mixed with ordinary coal gas in the foul main, where it takes up a considerable quantity of illuminants from the hot tar Methane hydrogen is claimed to take up benzene better than ordinary water gas in the carburetting process Such a carburetted methane hydrogen gas costs 8 92d per 1,000 cubic ft at Truro

Producer-gas. This term is applied to the gas obtained in the producer or generator of the water gas apparatus It will be remembered that air was passed into the generator filled with coke a gas was produced which was used to heat the second chamber, into which steam was driven and decomposed into water gas This may be taken as an instance of the utilisation of producer gas, but it finds many employments in metallurgical operations, boiler firing, gas engines and in glass and pottery manufacture It is also known as *Siemens' gas*, because producer gas was economically made in a regenerative furnace of the Siemens type The producer gas is made in numerous different furnaces In some the gas is enriched by being used for distilling coal and again it steam and air are injected a mixture of producer gas and water gas is obtained—the so called *semi water gas* or *Dowson gas* The amount of steam that can be used is limited from the reasons which we have dealt with in the paragraph on water gas—and is arranged so that the heat generated by the air equals the heat absorbed by the steam Producer gas contains a large proportion of nitrogen from the air that is injected and as nitrogen is a non combustible gas producer gas is comparatively poor in heating properties its flame also is non luminous The French call the gas *gaz pauvre*, or *poor gas* Although the gas is poor, it can be produced in large quantities and very cheaply On this account producer gas can be used freely, and still be an economical source of power. Carbon dioxide is also found in producer gas, but the object is to make carbon monoxide in preference, as only the latter is combustible Some average analyses will be given later in comparing the composition of several gases In many producers anthracite is used in place of coal, as the tar produced with bituminous coal entails purification plant, the gas having a clogging action when used in gas-engines if it contains tar.

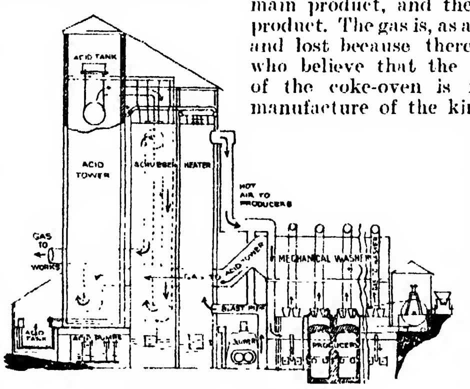
Types of Producers. The Bischof producer of 1839 is the basis of most types that have since been invented The Siemens' gas producer was brought out in 1861 These early types of producers had open ashpits with draught produced as in ordinary furnaces, and much heat was lost Succeeding types are provided with closed hearths, and are produced with numberless variations in the arrangement of the parts Prof A H Sexton divides closed producers into the following five groups (1) bar bottom (2) solid bottom (3) water bottom, (4) automatic (5) blast furnace The Dowson producer one of the best known of the bar bottom type was patented in 1878 (No 3997) and 1881 (No 2839) The air and steam were admitted through the bars The clinker from the fuel accumulates on the bars of the furnace and needs stoking to remove it The Wilson producer of 1876 (No 3949) is an example of the solid bottom producer The fuel rests on the solid bottom of the generator upon a layer of clinker The clinker is drawn off near the bottom and air blown in just above the layer of clinker which is always left in the producer The clinkers are removed every twenty four hours through narrow side doors bars being put across to support the fuel during the operation Solid bottom producers are thus intermittent, but this is got over by arranging a water seal as in the water-bottom producers The ashes fall into water, and no gas escapes The heat of the ashes vaporises some of the water which passes into the producer The Duff producer (patent 15646, of 1901), the Smith and Wincott producer (patent 12895 of 1901), and the Wilson water bottom producer are representative examples of this type In the automatic producers the ashes are continuously removed by mechanical means The Wilson automatic producer does this by a constantly revolving screw, which slowly pushes out the ashes Space will not permit of details being given of the numerous producers that have been patented and which fall under one or other of the above types The chief improvements consist in means of removing the tar from the gas heating the air and steam before use special methods of charging, special arrangements for supplying the air and steam, varieties in grates producers raising own steam, arrangements for breaking up clinker or fuel supplying the air and steam at the top and drawing off the gas lower down feeding at the bottom

Suction Gas-producers. The constantly increasing use of gas engines has ensured the evolution of the gas producers along economic lines The types hitherto dealt with have needed air and steam forcing into the producer with the consequence that the gas was under slight pressure, from which fact the type has been distinguished as *pressure gas producer* From these a new type requiring neither steam jet nor air blower has been evolved the air being drawn into the producer by a suction pump attached to the gas engine, being known as *suction gas producers* With the older type of pressure producers a boiler was needed to generate steam and a gasholder in which to store the gas for use while with the suction type the gas is taken direct to the combustion chamber of the engine The boiler is supplanted by an *evaporator* or *vaporiser*, which in small plants is built frequently on the top of the producer in the form of a water jacket, and in large plants close to the producer in the form of a tubular evaporator This evaporator is generating the steam required by utilising the waste heat of the producer and of the gas, which is of considerable advantage, as

compared with the old system, the firing of a separate boiler being dispensed with. The advantage of a suction gas-producer are automatic generation of the gas by the engine; highest and best utilisation of fuel; no boiler or gasholder required; can be erected without danger in any convenient place; easy to start and to run; no soot, smoke or odour; no explosion possible; and small floor space required. The origin of the type is the Benier producer, which was patented 1894, and has been specially developed on the Continent. A complete suction gas-producer plant consists of a blower which, up to 150-h.p., is driven by hand: a producer, an evaporator, an overflow water-pot, a scrubber, and a small equalising tank or *expansion box*. In plants above 75-h.p. a sawdust scrubber is advantageously inserted behind the wet scrubber, and in plants where two or more engines are fed from the same producer a small gasholder with automatic regulation is used.

The producer consists of an iron shell lined with firebrick and provided with a suitable hopper. The grate area, according to the quality of fuel, is 0·8 to 1 sq. ft. for every 10 horse-power. The scrubber consists also of a sheet-iron shell, and is filled preferably with broken coke. Before starting the engine the fuel in the producer is heated up by means of a blower until the gas is burning well at the test-cock. When this point is reached the blower is stopped, and the engine started in the usual way. The engine then draws by its own sucking action the necessary amount of air and steam through the fuel, and is producing its own power-gas. From the producer the gas is drawn through the scrubber and the equalising tank to the engine. The gas-making process continues so long as the engine is moving, and stops when the engine stops. Anthracite, charcoal, or coke can be used in suction gas-producers.

Mond Gas. Dr. Ludwig Mond, in studying the question of obtaining a cheap fuel gas, has evolved a method in which slack coal is used, and the ammonia produced by the combustion is recovered. The gas is really a producer-gas, but is, on account of the novel method of production, generally distinguished as Mond gas. The gas is being produced on an enormous scale, and is distributed by means of pipes in a large district in Lancashire. The following is a brief description of the plant used, which will be made clearer by referring to the illustration [10]. The producer is provided with a water-seal, and is constructed so as to allow the ash, which is the only residue, to descend into the water, from which it is easily removed without interfering in any way with the working of the producer. The process of combustion is carried out at a comparatively low temperature, with the twofold object of preventing the formation of clinkers in the producer and of providing against the destruction of ammonia. This is accomplished by introducing into the producer a blast of hot air and steam. The quantity of steam required when it is desired to recover the ammonia from the gas is equal to $2\frac{1}{2}$ tons per ton of fuel gasified, but of this about 1 ton is automatically recovered and used over and over again. After leaving the producer the gas is passed through a regenerator arranged so that part of the heat or gas and steam entering it is transferred to the blast of air and steam on its way from the air-heating tower to the producer, the gas being consequently cooled to a corresponding temperature. The gas then passes to a mechanical washer, which further reduces the temperature and removes all soot and dust. The next step is the recovery of the ammonia, and the gas is for this purpose passed through an acid tower, where the ammonia is completely absorbed by a dilute solution of sulphuric acid. The solution circulates through the acid tower again and again until it contains from 36 per cent. to 38 per cent. of sulphate of ammonia. Continuity of the process is provided by adding from time to time fresh supplies of sulphuric acid and withdrawing corresponding quantities of sulphate liquor. The latter is evaporated, yielding at once a solid sulphate of ammonia of good saleable quality. After the gas has been washed of its ammonia products, it passes through a final cooling and cleaning water-tower, and is then ready for use. As the gas is cooled in this final tower the steam with which it was saturated is condensed, and the cleaning water which enters the tower cold is delivered hot; and this, after passing through tar-separators, is again pumped to the air-heating tower to heat the air required for the producer blast. The final cost of 140,000 cubic ft. to 160,000 cubic ft. of gas from a ton of fuel is put at 4s. 11d. About 90 lb. of sulphate of ammonia is obtained from each ton of coal.



10. MOND'S GAS-PLANT

Coke-oven Gas. In the manufacture of coal gas, as we have seen, the gas is the main product, and the coke, although used for several other purposes, is the by-product. The iron smelter requires a coke that is compact, heavy and even, and to produce such a coke special furnaces are used, known as *coke-ovens*. Here the coke is the main product, and the gas given off is the by-product. The gas is, as a rule, completely neglected and lost because there are many iron makers who believe that the recovery of the products of the coke-oven is not consistent with the manufacture of the kind of coke which is most suitable for the blast furnace. As some 13,000,000 tons of coal is coked in the United Kingdom in beehive ovens for the manufacture of pig iron, it will be apparent that the loss is tremendous. Many recovery or by-product coke-ovens have been invented, the principle being that the gas is drawn away from the ovens and means employed to remove the tar and ammonia. The resulting gas can be used for heating the coke-ovens or for other industrial purposes, such as in gas-engines. In large installations of by-product coke-ovens two kinds of gas are separately collected; the richer gas coming off during the first part of the process can be used as an illuminant, the second portion of the coking yielding fuel gas. The other by-products, tar and ammonia, are recovered by similar methods to those used in purifying coal gas, and described a little further back.

Blast-furnace Gas. The blast furnace used for smelting iron ore generates a large quantity of inflammable gas known as *waste gas*. The last name expresses the universal practice of iron makers up to a few years back, when efforts were directed to utilising this wasted form of fuel. The gas, owing to the velocity with which it passes from the furnace, is laden with dust, but this is neglected when the gas is employed for heating the blast, or as fuel under boilers. When required for use in gas engines the gas must be cleaned, or it soon blocks up the valves of the explosion chamber. Properly cleaned furnace gas is an ideal gas for gas engines, as when mixed with air and compressed, it is found to be a slow but very reliable explosive. A portion of the gas is used for driving the gas engine which produces the blast, but much surplus gas remains for other economic purposes.

Composition of Gas. The following typical analyses of illuminating and fuel gas are interesting as showing the relative composition. The figures (percentages) were given by Mr. Willard L. Case in a communication to the New York section of the Society of Chemical Industry in 1905.

from moisture—large quantities in strong iron drums, and small quantities in hermetically sealed tins. This property also accounts for the fact that the storage of calcium carbide is regulated by the Petroleum Act, except when quantities of 28 lb. in 1 lb. packages are stored.

Properties of Acetylene. The light yielded by acetylene more nearly approaches sunlight in light rays, but it has more blue or violet rays (chemical rays). The illuminating power of acetylene is compared with coal gas varies with the type of burner employed. In a suitable burner, 5 cubic ft. of acetylene per hour will give 240 candle power, while the same quantity of coal gas gives 16 candle power. Acetylene is, however, generally burnt in small burners using from ½ cubic ft. to 1 cubic ft. per hour, when the illuminating power is from six to ten times as great as that of coal gas. There is less heat developed by combustion of acetylene for given yield of light than most other illuminants. The distinctive smell of commercial acetylene makes it easy to detect leaks. The limits of explosibility of acetylene mixed with air are 3.1 per cent. to 24.1 per cent., which is a slightly wider range than other combustible gases of commerce. The effects of an explosion would probably be no

COMPOSITION OF ILLUMINATING AND FUEL GASES

—	Natural gas	[illegible]	[illegible]	Water gas	[illegible]	[illegible]	[illegible]	Coke	[illegible]	Blast furnace gas
Hydrogen	3.0	46.0	[illegible]	45.0	40.[illegible]	[illegible]	10.0	10.0	50.0	1.0
Methane	92.0	40.0	48.0	2.0	[illegible]		3.0	—	36.6	—
Ethylene	3.0	5.0	[illegible]		[illegible]		[illegible]	—	4.0	—
Carbon monoxide		6.0		8.0	19.[illegible]	25.0	23.0	2[illegible]	6.0	27.5
Carbon dioxide		[illegible]	—	6.0	3.0	[illegible]	[illegible]	4.[illegible]	1.[illegible]	11.5
Nitrogen	2.0	2.0	[illegible]	[illegible]	4.0	49	8.0	[illegible]	2.0	60.0
Oxygen		[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	—

Acetylene. At the beginning of the consideration of illuminating gas acetylene was mentioned as both a combustible and luminous gas present in small quantities in coal gas. Acetylene has, within recent years, been prepared for use by itself as an illuminant, this having been rendered possible by the discovery of a cheap method of producing it.

Action of Water on Carbides. When water is brought into contact with calcium carbide acetylene is produced in accordance with the following chemical reaction:

$$CaC_2 + 2H_2O = Ca(OH)_2 + C_2H_2$$

calcium carbide   water   calcium hydrate   acetylene. The production of the gas is so easily and simply effected that it is no wonder that the use of acetylene soon became popular in places where coal-gas or carburetted water gas were unattainable. Besides calcium carbide there are other carbides prepared in the electric furnace but none of them have assumed the importance of calcium carbide. Lithium carbide, barium carbide, strontium carbide, potassium carbide, and sodium carbide all give off acetylene when brought into contact with water, but aluminium carbide gives off methane and manganese carbide, a mixture of methane and hydrogen. Attempts have been made to take advantage of the last-named carbide by mixing manganese dioxide with the ingredients for making calcium carbide, but, so far, the production of mixed carbides has not been successful.

Storage. On account of this action of water on calcium carbide it is necessary that it be stored

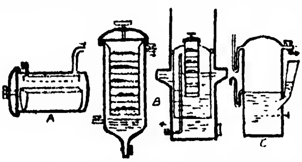
greater than with ordinary gas. Compressed acetylene is dangerous and its manufacture, importation, or storage at greater pressure than 100 in. of water is illegal in the United Kingdom. Acetylene is, however, allowed to be compressed along with oil-gas, as the mixture has been demonstrated to be safe. The exemption extends also to acetylene compressed into porous material, both with or without acetone. The last named liquid has the power of absorbing 250 volumes of acetylene at a pressure of 10 atmospheres, the liquid being known as *dissolved acetylene*.

Impurities in Acetylene. It is the impurities in acetylene which give the gas its unpleasant smell; hence every care needs to be exercised to use only pure ingredients in making calcium carbide. Phosphorus compounds in the lime used become calcium phosphide, which, when moistened with water, yields phosphine; this gives not only an unpleasant odour, but also a white haze of ammonium phosphate in the air when burnt in a closed room. The highest proportion of phosphine ever met with has been 2.3 per cent. Sulphur compounds are seldom present, but sulphuretted hydrogen may be detected in cases where the gas has been improperly generated or where aluminium sulphide is present in the carbide. Crude acetylene always contains ammonia, which arises from the aluminium or calcium nitrite in the carbide. It is an objectionable impurity, as it corrodes the brass fittings, and, producing pyrol at the burners, stops them up. Traces of hydrogen silicide, oxygen, nitrogen (or air), hydrogen, carbon monoxide, and

methane, have also been found in varying small amounts.

Purification of Acetylene. The substances which have been proposed as chemical purifiers for acetylene are (1) ordinary ferric hydroxide, as used for coal-gas; (2) heratol, a solution of chromic acid in acetic or sulphuric acid absorbed in kieselguhr; (3) acagine, a mixture of bleaching powder, with 15 per cent. of lead chromate; (4) puratylene, a mixture of bleaching powder with calcium chloride and calcium hydroxide; and (5) frankoline, a solution of copper and iron chloride absorbed by kieselguhr. These materials have been subjected to an examination and tested for efficiency by Keppeler, and were, as a result, placed in the following order: Ferric acid is practically useless, but one kilo of the other four materials purifies the following quantities (in litres) of acetylene; heratol, 5,000; frankoline, 9,000; puratylene, 10,000; acagine, 13,000. In practice, these numbers may be increased from 10 per cent. to 20 per cent.

Types of Generators. There have been up to the present time some hundreds of different apparatus [11] constructed for the purpose of generating acetylene from calcium carbide. These have been classified by Professor V. B. Lewes into the following three classes, into one or other of which all the generators at present on the market fall.



11 TYPES OF ACETYLENE GENERATORS

1. Those in which water is by various devices allowed to drip or flow in a thin stream on to a mass of carbide, the evolution of the gas being regulated by the stopping of the water-feed.

2. Those in which water in volume is allowed to rise in contact with the carbide, the evolution of the gas being regulated by the water being driven back from the carbide by the increase of pressure in the generating chamber.

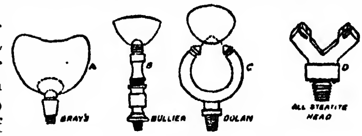
3. Those in which the carbide is dropped or plunged into an excess of water.

These types are again subdivided into (*a*) *automatic* and (*b*) *non-automatic*.

By automatic generators are meant those which have a storage capacity for gas less than the total volume which the charge of carbide is capable of generating, and which depend upon some special contrivance for stopping contact between the water and carbide. Non-automatic generators are those in which a holder of sufficient capacity is provided to receive the whole of the gas made from the largest charge of carbide which the apparatus is capable of taking.

Choosing a Generator. The factors to consider in choosing a generator are those which guided the Departmental Committee appointed to advise the Explosives Inspectors in 1900. The Committee consider that in selecting an acetylene generator regard should be had to the following desiderata: (1) simplicity of action and design; (2) strength of construction; (3) high efficiency, as indicated by the yield of gas per lb. of carbide; (4) low pressure in generator; and (5) facility of removal of the residue.

Acetylene Burners. One of the chief difficulties in the burning of acetylene is the quantity of smoke which is produced, which causes endless trouble by growths of carbon which form at the tips of the burners. Burners using 0.75 cubic ft. to 1 cubic ft. of acetylene per hour are the largest that can be used without unpleasant effects. The acetylene is mixed with air at the burner in the most successful type, an air intake being arranged at the tip of the burner. The Naphey is a popular kind. In this, two small jets of acetylene meet to form a flat flame, with very little tendency to produce smoke or become choked. Other types are shown in 12.



12. TYPES OF ACETYLENE BURNERS

Installation Hints. As there are many points of difference between the fittings used for coal-gas and acetylene, the requirements are briefly indicated separately. The generator and holder should be in a well-ventilated place outside the house, the place being capable of being warmed with hot-water pipes in case of severe weather. The holder should be of such a size as to contain sufficient gas to last the whole evening or the longest period the burners will be alight. As regards the size of the pipes used for supplying acetylene, it must be remembered that a given size pipe will supply three times as many burners with acetylene as with coal-gas. For fifteen burners ½ in. pipe is used; for sixty burners, ¾ in. Iron barrel piping should be used, and joints screwed together without paint or packing. Taps require to be of best quality brass, as cheap fittings are soon corroded. In starting an installation, care must be taken that all the air is out of the pipes. It is best to take samples of gas from each burner in a test tube, and test with a match before applying a light to the burner for the first time. The pressure at which the gas is supplied should not be more than 2½ in.

Yield and Cost of Acetylene. One pound of calcium carbide will yield 5 cubic ft. of acetylene; in practice it is usual to reckon the quantity as 4 cubic ft. Acetylene is reckoned to cost £2 per 1,000 cubic ft. in the holder, and if it is distributed on a commercial scale, the cost of distribution will double this. Coal-gas costs 1s. 2d. per 1,000 cubic ft. in the holder, this being doubled by the expense of distribution and profit. It will thus be seen that acetylene cannot displace coal-gas where the latter is obtainable.

Acetylene Lamps. Many kinds of portable acetylene lamps have been devised, but the great difficulty in the case of table lamps has been to ensure freedom from smell. It will be obvious that similar conditions and principles apply in constructing table lamps as are indicated in the case of generators. It is usual to arrange a filter of silicate wool before the acetylene is passed into the burner, so as to guard against mechanical impurities being taken into the flame. Acetylene cycle lamps are much in use on account of the brilliant illumination obtained. Such lamps are more expensive to maintain than oil lamps, and the greater light obtained is not always a recommendation. Acetylene motor lamps are a development of the cycle lamps.

Gas Meters. To measure the quantity of gas used by a consumer, gas is passed through a meter which mechanically records the volume of the gas. The meter is fixed within 2 ft. 6 in. of the main cock. The gas is measured in cubic

feet, for which, curiously enough, no standard existed till the passing of the Sale of Gas Act 1859 This Act fixed the standard cubic foot as the space occupied by 62·321 lb avoirdupois of distilled water, weighed in air at 62° F, and at normal atmospheric pressure Meters are tested for accuracy by passing through them a measured volume of gas from a small gasholder The following are the capacities of a few ordinary size meters

Size	[illegible] inlet and outlet [illegible]	Measuring [illegible] per [illegible]	[illegible]
	in	ft	ft
10 light	1	½	60
20 ,,	1¼	1	120
30 ,,	1[illegible]	1½	180
51 ,,	1½	2½	300
100 ,,	2		[illegible]00
250 ,,	4	12½	1 [illegible]00
1 000 ,,	7	[illegible]0	6 000

Wet Meters. There are two types of meters in use, the wet meter and the dry meter The former is constructed on the model of the station meter and consists of three essential parts (1) a hollow drum or wheel rotating in water through this drum the gas passes, and as the drum rotates it actuates the dial index recording automatically the gas passed, (2) a compensating arrangement for keeping the chamber in which the drum revolves at a constant level and (3) the index which shows the amount of gas passed The measuring wheel is of inflexible material, but the water in the meter is liable to freeze in cold weather For this reason the meter requires to be protected from change of temperature and as an additional precaution glycerine is added to the water to lower the freezing point Salt, magnesium chloride and calcium chloride are sometimes used in place of glycerine but corrosion of the interior of the meter often results

Dry Meters. This type of meter works on the principle of an ordinary bellows Gas enters and leaves compartments having flexible leather sides alternately through valves which open and shut at the proper moment One of the best known makers of dry meters thus describes his make of dry meter

It consists of a cylinder divided by a plate in the centre into two separate cylindrical compartments which are closed at the opposite ends by metal discs these metal discs serve the purpose of pistons and they are kept in their places by a kind of universal joint adapted to each the space through which the discs move and consequently the means of measurement is governed by metal arms and rods, which space when once adjusted cannot vary To avoid the friction attending a piston working in a cylinder, a band of leather is attached which acts as a hinge and folds with the motion of the disc this band is not instrumental in the measuring so that if it were to expand or contract, the registering of the meter would not be affected, inasmuch as it would only decrease or increase the capacity of the hinge the disc being still at liberty to move through the required space the leather is also distributed in such a manner being curved and bending only in one direction that it prevents any creases or wrinkles forming, and renders it therefore much more durable The arrangement of the valves and arms are somewhat different to that of the steam engine, although somewhat similar in principle

Most dry meters are composed of two chambers, but there may be three or more, without difference of principle The chambers fill and discharge alternately or in succession, and the action of the valves is accurately registered in the mechanism that regulates the dials of the index. A common error is the supposition that the leather enclosing the space between the discs actuates the gas, but the whole of the work is performed by the latter, which are really pistons receding to let the gas fill the chamber and advancing to drive it out Though delicately adjusted, the mechanical action is really very simple

How to Read the Meter. There is no mystery about the dial of a gas meter It is perhaps because some people have never considered the subject that they think it difficult to read a gas meter. It is as simple as telling the time by a clock There are three or more dials in the little compartment at the top of the meter One of these indicates, perhaps 2 cubic ft an arrow usually being placed to indicate the direction of the hands When a large quantity of gas is being burnt the little hand in the unit dial is kept busy and the consumer can get a good idea of the cost per hour of, say, a cooking stove The other dials register hundreds, thousands, ten thousands and million cubic feet the hands moving on the dial just as on the smaller dial, but naturally much slower At a given date—say, the beginning of a month—the quantity is noted, and at the end of the month the index is again read off the difference between the two amounts being the quantity consumed during the month In the case of illuminating devices used at public rejoicings the gas is generally taken direct from the main and a charge made of so much per jet per hour, with a minimum charge of 50s

Prepayment Meters. These meters, which are actuated by a coin are also known as slot meters They were invented in 1887 and are of various kinds—Brownhill's Price's Cutler's Braddock's, Cowan's Glover's and Parkinson's—adapted for taking either pennies sixpences shillings, florins or half crowns The slot meter is extremely popular with people of moderate means who can thus use a cheap illuminant without running into debt

Slot-meter Mechanism. At the front of the meter is the slot Within is a delicate balancing arrangement which works on the valve of the meter This balance is connected with the index and as soon as the drum cylinder has revolved the allotted number of times the balance is disturbed and the coin drops down and the supply ceases As meters are made to give out quantities of gas for a six pence a shilling a florin or half a crown it is easy to see that the weight of the coin, except as a means of starting the action has nothing to do with measuring the gas

Gas-fitting. From the meter pipes convey the gas to the various parts of the house The supply pipes are best of wrought iron but composition pipes are much used The latter are more liable to damage and many cases of leakage have been caused by nails having been driven into the softer piping The liability to compression and consequent constriction in the supply of gas is another fault often found with composition pipes Cheap piping is to be avoided as soundness is a very necessary quality in gaspipes All lines of piping should be laid with a gradient so that condensed moisture can drip or drain back into the risers Drip pipes should be provided where necessary Piping should be exposed as much as possible to facilitate future examination and where the pipes are laid beneath floors the boards should be screwed and not nailed down In searching for leaks in pipes, a light should not be used, but the suspected parts painted with a strong soap solution, bubbles will show themselves if the least trace of gas is escaping The work of the gasfitter has been described on pages 5797 to 5799

GAS *concluded*

Continued from page 6678

BUSINESS SIDE OF GARDENING

Economical Gardening. The Oldest Profession on Earth. Nurserymen and Seedsmen. The Market Gardener and his Opportunities. Profits and Losses

By H. H. HAVART

WHETHER a garden be large or small, its economical management depends so much on soil, situation, and other circumstances, that no hard and fast rule can be laid down to apply equally in all cases. Particularly does this apply to suburban gardens. There are some, notably in the western suburbs of London, attached to houses built on the site of market gardens, the soil in which is naturally good, and where but little in the way of manure is needed every year.

The Cost and Economy of the Small Garden. The initial cost of forming such a small garden, too, depends greatly on the condition in which the builder of the house has left it, or, if the house is not a new one, on the horticultural tastes of the previous tenant. Assuming that the ground is not in a very rough state, the following figures will serve as a guide to the initial outlay necessary:

	£	s.	d.
Jobbing gardener, two days weeding, digging, and preparing ground at 5s. per day	0	10	0
Spade, rake, etc.	0	8	0
Lawn mower	0	14	6
Loam, leaf mould, potting soil, for improving ..	0	12	6
Manure	0	6	0
Small collection of vegetable seeds	0	2	6
Small collection of bulbs	0	5	0
Small collection of hardy annuals and perennials	0	5	0
Fruit and rose trees and shrubs (say)	1	0	0
	£4	3	6

This figure does not, of course, represent the annual expense, which may, in subsequent years, be limited to practically the 12s. 6d. comprising the seed and bulb items, as fruit and rose-trees rarely require renewing. The item for manure, too, is one which need not recur often. In fact, in many cases, a tradesman who supplies the household with goods will be only too glad to give a load or so of horse manure, if asked for it.

A greenhouse, with its accompanying heating apparatus, and a frame constitute a serious item. An efficient greenhouse for a small garden would be one (say, 9 ft. by 6 ft.) costing about £4, and the necessary heating apparatus another £3. A handy-sized frame, 8 ft. by 6 ft., costs £2 15s. The prices given are those for the simplest form of house and frame, and may be taken as being the lowest at which an effective greenhouse can be established.

Economy in Vegetables and Fruit. The most economical thing that can be grown in any small garden is undoubtedly the scarlet-runner bean. A shillingsworth of these, sown at intervals of a fortnight throughout the spring, will yield sufficient for the needs of a small family throughout the summer, and on into the autumn—that is, assuming that they take their turn with other vegetables. It is waste of time to try and grow such vegetables as cauliflowers and cabbages in a town garden. Radishes, lettuce, and mustard-and-cress are most economical vegetables for town-garden culture, and, at a rough computation, a shillingsworth of crop may be expected for every pennyworth of seed sown, provided ordinary care is used in thinning out and other details.

Pears thrive in town gardens much more readily than apples, while crops of cherries and plums are usually spoiled by the attacks of birds. Of the bush fruits, the gooseberry is most likely to yield a profitable crop under such conditions. Strawberries are not to be thought of except as a hobby, as they take up a large amount of ground for a yield which is small in comparison. The ground they would occupy is best covered with small saladings.

Economy in the flower garden is to be effected by its help in furnishing flowers for indoor decoration, and for "buttonhole" purposes. In planting a small garden for economy, it is not at all necessary to put the things in formal rows, as if planting for market purposes. Those flowers which yield large supplies of bloom for cutting purposes should be interspersed with such things as geraniums, calceolaria, lobelia, and the like, which, though not so adapted for filling vases, lend bright colour to the garden generally: hence, when occasion arises to cut the flowers in the garden with a free hand, the presence of the things just mentioned will conceal the bareness which their absence would only serve to accentuate.

Economical Management of a Large Garden. The economical management of a garden depends almost entirely on the selection of a head gardener, and in this connection it often happens that the best horticulturist is not the man most suited to control a staff economically, and get the maximum amount of produce out of the ground at the minimum expenditure of money.

A young gardener who hopes to rise as high as possible in his profession should be careful not to lose sight of the commercial side of it. The days when an owner of a country seat simply gave orders for a garden beautiful, without counting the cost, are over. Certainly, owners of gardens take much more personal interest in them than hitherto, but the commercial spirit of the age has entered into gardening as deeply as into many another hobby, and, although it seems sordid to say so, the head gardener who can make the biggest show of bloom at the cheapest rate is the man who will get on.

Economy in labour is one of the most important items in the management of a large garden, and here the individual who calls himself a "head working" gardener will be out of place. In an establishment of any pretentions, where the number of hands employed in the gardens may be anything from twelve to forty, it is a false economy on the part of the head, as a rule, to do any of the manual work himself. It must not be forgotten that, in the majority of gardens, a large section of the staff will be composed of boys and young men, with little or no sense of life's responsibilities, and that the temptation to idle away their time when no watchful eye is upon them is one too great to be resisted. Instead of actually doing things himself, therefore, the head gardener should spend a large portion of his time in seeing that others do them as he would wish. It is a false economy to employ young and comparatively inexperienced men as foremen. Next to the head himself the well-doing of the garden is in the hands of

these men, and, though it may look well on paper to show a few pounds saving at the end of a year in this part of the wages list by employing low-priced hands, it is of very little use when there is a much bigger item on the other side of the balance-sheet for plants and other things which have been spoiled by careless handling.

Seed-saving. An important item in the management of a large garden is that of seed-saving. Seed of all flowers and vegetables that do well in a garden should be saved every year, and be stored away for sowing the following season. Careful attention to this branch of the garden work will effect a saving of many pounds on the annual seed bill, and the work of picking them over in order to separate the good from the bad is an operation which may readily be carried out during the winter days when there is not so much to be done out of doors, or at any time when inclement weather causes a cessation of operations outside. It is not economy to be constantly introducing novelties into a garden. Changes must, of course, be made from year to year, but thousands of pounds are wasted annually in this country in the purchase of seeds, plants, and bulbs which are boomed as being something new.

It is not too much to say that an economy of 25 per cent. can be effected in the cost of fuel for the hothouses where care is used. Sufficient fuel must, of course, be used to maintain the houses at an adequate temperature, and anything more than that is not only waste as far as the consumption of fuel is concerned, but is not in any way conducive to the welfare of the inhabitants of the greenhouses. It should not be forgotten that coal-dust, damped with a little water, and banked up in the boilers overnight, will preserve an equable temperature in a house till morning, without further attention. This is a far more economical plan than the general one of stoking up overnight with a mixture of coal and coke, which invariably has the effect of raising the house many degrees above its proper temperature during the early hours of the night, and letting it down dangerously by the time the darkest and coldest hour of all arrives—the one preceding dawn.

A watchful eye must be kept on what is erroneously called the rubbish heap. It is a common practice to throw away bulbs that have been forced, plants which have been pulled up in the process of thinning out beds, and other such things. All forced bulbs may be used again in a spot in the reserve garden to furnish a supply of bloom for cutting, and if there is no room for surplus bedding plants, or thinned-out vegetables, they may readily be exchanged or got rid of in other ways.

How to Label. Proper labelling of plants is a far more important factor in the economical management of a garden than is generally imagined. Except in the case of plants which are so generally grown that they cannot fail to be recognised by the merest tyro, it is well to have everything labelled inconspicuously, but at the same time clearly. This is particularly important in gardens where collections of the different species of a genus are made, as, although many of them are very similar in appearance, they require different treatment from each other. In the event of a mistake, therefore, it is easy to see that a lot of valuable plants may be lost through not being labelled at all, or labelled indistinctly. It may be well to state here that the writing on a label should always be commenced at the top end—that is to say, at the part of the label furthest from the point which sticks into the ground. The reason for this is that if the rain and decay tend to make the label illegible, the upper part of it is, in the ordinary course of events, sure to be clearer than that which is close to the ground. If this upper part, therefore, bears the first part of the name of a plant, it is usually easy to guess at the remainder; but if the writing of the label has been started at the lower part, in all probability the last few letters of it only will be legible, and confusion easily follows.

The Need for Tidiness. It need perhaps hardly be said that tidiness and economy go hand in hand in gardening. All such operations as weeding, rolling, mowing, the clipping of hedges, and the hundred and one operations which go to make the garden neat and pleasing to the eye, should be attended to promptly and frequently. It is easy for a lad to remove young weeds, for example, in a very short time when they first make their appearance, but if they are allowed to remain undisturbed for a few days, it is astonishing with what rapidity they will grow, and with what corresponding difficulty and expenditure of labour their removal will be attended. That well-known business maxim, "Do it now," cannot be too rigidly observed in connection with the gardening operations just alluded to if a true economy of time and labour is to be effected. On the other hand, it is well not to be too precipitate with the autumn and winter planting operations, and the carrying out of such schemes as summer bedding. The vagaries of the weather have to be considered here, and too much promptness in the work may allow a nip of frost to destroy everything, and hence, instead of an economy being effected, a further expense for new plants is incurred.

How to Become a Gardener. Although the oldest profession on earth, gardening is one which is most poorly paid, and the lad who is setting out with the determination to make a fortune should think very deeply before he decides to embrace horticulture as the means to that end. This remark applies more particularly to private gardens. There are plenty of instances on record of nurserymen who have accumulated large fortunes, and, although the market gardener is always pleading poverty, one very rarely sees members of his profession included in the official list of Receiving Orders in Bankruptcy; but in both these businesses there is, of course, a large element of risk. To qualify as a gardener it is necessary to start young. The orthodox way is to secure a berth in some large local private garden or nursery as a boy, at a wage which rarely exceeds 5s. per week. If a lad shows any aptitude the head gardener will be only too glad to push him on, and, in a couple of years time or so, his money will be raised to 7s. or 8s. a week, in addition to living accomodation in the "bothy." This "bothy" is usually a small cottage in which the young unmarried gardeners in a private establishment live together, and take it in turns to act the part of housekeeper. If the "improver," as the embryo gardener is called at this stage, lives at home instead of in the "bothy," he is usually paid a shilling or two more per week. As he grows older and gains more experience he develops into a "journeyman." There is no doubt that at this time he gains the bulk of his experience, and if he wishes to learn his profession thoroughly he will do well to change his situation occasionally, and become acquainted with gardens in various parts of the country.

It must be distinctly understood here that the writer does not wish to advise lads and young men to throw up good situations, and go wandering about the

face of the land in and out of work every few weeks. If a gardener is in a situation which seems likely to be a permanent one, and the prospects of promotion are good, he will, of course, stay there if he is sensible. At the same time, experience gained in only one garden cannot be so varied or valuable as that obtained in two or three, where soil, aspect, climate, and dozens of other conditions vary.

Getting to the Top. By the time he is four or five and twenty years of age, the "journeyman" usually considers he has sufficient experience to dub himself a "foreman," and in this capacity he has charge of one part of the garden, under the immediate supervision of the head gardener. The number of foremen employed in a garden varies, but in a place of any pretensions there is usually one for the kitchen garden, one for the flower garden, and a third for the glasshouses and conservatories. His wages are now about £1 per week, and his share in the "bothy," or 24s. a week, roughly, if he lives outside. The final step from foreman to head gardener usually happens automatically, when the horticulturist is lured into matrimony. He finds that a foreman's wage is not sufficient to support two, and therefore he endeavours to better himself by applying for a situation as head gardener. When he has succeeded in obtaining this he has risen as high as he can ever hope to do in his profession. His emoluments now consist of a salary of 30s. a week with a cottage to live in rent free and the privilege of having sufficient of his employer's coal, fruit, and vegetables, for the consumption of himself and family. There are very few gardeners indeed in the United Kingdom who, though they may have charge of places in which thirty or forty men and boys are at work, receive a higher wage than that just mentioned, an income which, in cash and kind, rarely exceeds £150 a year.

Growing for Exhibition. Growing for exhibition at flower shows is another of the gardener's methods of increasing his income if his employer does not object. There is hardly a village in the United Kingdom that does not hold its annual flower-show, and many gardeners exhibit at every show within a reasonable radius. The prizes are not large, certainly, ranging as they do from a shilling to a sovereign, but they amount to a considerable aggregate with a consistent exhibitor. The majority of employers are very willing for their gardeners to compete at these flower shows, and willingly buy exhibition varieties of different plants to facilitate their chance of winning, thinking, as they rightly do, that success at flower-shows is a proof of the skill of their gardener, and an incentive to spur him on to further efforts. At the same time, however, it must be remembered that too much showing is a bad thing. A head gardener who is constantly exhibiting is apt to devote too much attention to his "show" plants, to the detriment of the garden work generally, while his constant absence at the shows themselves, brought about by the necessity of staging and removing his exhibits, is likely to make things get slack in the garden all round. Exhibiting, therefore, should only be done in moderation.

How to Succeed as a Nurseryman and Seedsman. The difference between a florist and a nurseryman and a seedsman is a simple one. The florist is not a producer, but is generally merely an agent for the disposal of goods grown by other people. The nurseryman and seedsman, on the other hand, sells plants and seeds which are the result of his own cultivation and skill. It must not be imagined, however, that nurserymen sell nothing but what they have raised themselves, as large quantities of seeds and bulbs are imported annually, chiefly from Germany, France, and Holland, to enable them to fill orders which they could not execute from stock of their own raising [see also SEEDSMEN, page 4995].

Roughly speaking, nurserymen and seedsmen may be divided into three classes. At least 70 per cent. of them do the bulk of their trade in penny and twopenny packets of seeds, and cheap bedding plants. About 20 per cent. of the remainder have a better class of trade, an important feature of which is the laying out and keeping in order of suburban gardens by contract. The remaining 10 per cent. or thereabouts represent the elite of the trade, who, as a rule, supply only seeds of the finest quality, grown by themselves, and the latest novelties, for which they can command high prices.

How to Start. At the present time, undoubtedly the best situation for a nurseryman and seedsman who contemplates starting in business is in the outer suburbs of London or one of the other great cities. In such a situation he will be able to grow plants and produce seeds, free from the taint of city smoke, though, at the same time, they will be hardy enough to withstand the rigours of town life. A large portion of his trade will be purely local, although the postal department of a nurseryman's trade is one which ought never to be neglected. Naturally, the greater portion of the stock of a seedsman who caters for the million will have to be purchased by him from the wholesale houses in bulk, and made up and retailed in small quantities. Much of the success of the retailer will depend on the quality of the seed he thus dispenses. If he is careful to deal with wholesale firms of high standing, whose names are a guarantee of the goods they supply, our young nurseryman is, at all events, sure of giving satisfaction to his customers.

A certain amount of seed of such things as calceolaria, petunia, lobelia, and other popular plants should be sown very early in the year in heat with a twofold purpose in view. Some of the plants so raised will be required in the late days of spring and early summer, either for selling to chance customers, or for the purpose of fulfilling any contracts to keep gardens and window-boxes in order which the nurseryman may have been fortunate enough to secure. Keeping gardens in order by contract is a very profitable branch of a nurseryman's business, and a good trade may often be done in this direction by a local canvass of likely houses during the months of April and May.

Mail Order Business. If this branch of his industry should at first not come up to his expectations, there is another channel through which the nurseryman can dispose of any plants he may have on hand. This is by means of advertisements in the horticultural journals, bearing always in mind the fact that the nurseryman should draw up his advertisement with a view to disposing of what he will have ready for sale in a fortnight or three weeks' time. Most horticultural journals go to press at least a week in advance, and the consequence is that plants, which may be ready for disposal at the moment of drawing up the advertisement, will be past their best time for transplanting when the announcement is made public, and orders begin to come in. Intelligent anticipation will do much to assist in this branch of the business, but if, as sometimes happens, an unexpected storm or a late nip of frost injures or destroys the plants upon which

hopes of profit have been built, the best plan is to return the money for orders which cannot be filled from the nurseryman's own stock.

The Bulb Trade. The large majority of bulbs sold in this country every autumn are of Dutch origin, though within recent years it is pleasing to know that in the Lincolnshire Fen district, and in some parts of Ireland, bulb culture has met with no uncertain measure of success. Comparatively little wholesale trade is done, however, as most of the growers supply the public direct. In the days to come, however, there is but little doubt that the English and Irish bulbs will oust the Dutch bulbs from the market, especially as far as the better and choicer sorts are concerned. In the meantime, it is well to deal only with Dutch firms who will guarantee their bulbs as being true to name. A nurseryman should never hesitate about stocking bulbs liberally, as he has two chances of selling them. Those which are not got rid of by the end of November, when all bulb planting should cease, should be potted up and hurried on in a slight heat, when they will readily sell in the very early spring for decorative purposes, as the garden, and often the greenhouse, are comparatively bare of flowers at this time of the year unless they have been well looked after.

It should not be forgotten that one of the most profitable branches of a nurseryman's business is the "buttonhole" trade. To cope with this branch as far as possible, special efforts with winter-flowering carnations and roses in pots should be made, as these two flowers are in the greatest demand. If sufficient cannot be grown on the premises, without undue encroachment on valuable space, supplies may easily be augmented by French and Channel Islands flowers, which arrive at Covent Garden Market and other great centres of distribution in large quantities during many months of the year.

The Market Garden. The market gardener is not troubled much by winding paths and pretty effects. Concerning that part of his ground which is destined for open-air culture, the great aim of the market gardener, after such ground has been dug and prepared, is to maintain a proper rotation of crops, especially as far as vegetables are concerned. To this end the same vegetable will be grown on the same piece of land only once in every fourth year, so that the different chemical elements in the soil may adjust themselves and preserve the ground from becoming impoverished, at the same time effecting a large saving in the bill for animal and artificial manures.

There are a few points of especial importance if one wishes to succeed as a market gardener. It is well, to some extent, to specialise. A man stands a far better chance of success if he goes in for growing just a few things; say, for the sake of argument, grapes, tomatoes, and the choicer stone fruits on a large scale, than he does if he potters about with little patches of half a hundred different things which have cost him far more, in proportion, to bring to perfection, for which he will have a difficulty in finding a market. Salesmen do not care to handle small parcels of goods of which the carriage practically swallows up the profits.

The Opportunities of Extra-season Crops. Another point which the market grower should watch is not to devote all his attention to "main crop" things, but pay attention to early and late sorts. For instance, who has not lamented the shortness of the strawberry season? To the man in the street it is heralded by the appearance of choice fruits at two or three shillings for a small basketful. In a fortnight's time there is such a glut of the berries that really excellent fruit may be purchased at fourpence or sixpence a pound, and then all is over, and what cannot be eaten has to be destroyed or rushed round to the jam factories.

If many of these growers had devoted their attention to earlier and later sorts, there would have been a longer and steadier demand at better average prices, and less risk of the fruit spoiling without finding a purchaser. There is no difficulty about this. At the headquarters of the strawberry world, close to Bedford, it is quite possible to have strawberries any day in the year, and though an all-the-year-round strawberry trade is not to be recommended, it would be quite easy to lengthen profitably the present season.

Raising New Varieties. The raising of new sorts of fruits and vegetables can be made a source of profit to the market grower. Potatoes, for example, lose their character in the course of a dozen or twenty years and give way to disease, while tomatoes, strawberries, and many florists' flowers, such as roses, chrysanthemums, and carnations also deteriorate in quality and need to be replaced by good new sorts. It is a fact that a couple of seasons ago the now world-famed Eldorado potato changed hands at the rate of £22,400 a ton, while another variety, Northern Star, was for a brief period sold at the rate of £4,500 a ton.

When laying out the market garden, however, it is not wise to reserve too large a piece for experimental purposes. To attempt to raise an improved new potato is very much like taking a ticket in a lottery, there are so very few prizes and so many blanks. Cautious growers, who have made up their minds not to soar above the limitations of a moderate income, will carefully ignore the experimental ground altogether, and content themselves with buying stock of any desirable novelty from the lucky raiser.

The Profit and Loss Sides of a Market Garden. Within the last few years many thousands of acres of agricultural land have been diverted from the purposes for which they have hitherto been employed, and used for raising crops of fruit and vegetables for market. The Board of Trade returns show that this acreage is increasing every year, a fact which goes some way to show that the occupation is a profitable one, an assumption which is further borne out by the curious reticence of professional market gardeners at all times to give any reliable figures for publication.

As far as his profit and loss is concerned, the market grower is largely at the mercy of the weather, and it is not only bad weather that he has to fear. Storms, winds, and other inclemencies, will, of course, retard progress and tend to produce only scant and immature crops—a source of considerable loss, as the expenditure for labour, manure, and materials is just as heavy as in the case of a generous yield. Too favourable weather also is not a source of unmixed satisfaction to the market grower. It means a full crop, certainly, possibly a glut, and when this happens the prices realised immediately fall so low that there is little or no profit for the grower.

In all market gardens where there is a large amount of glass for growing cucumbers, tomatoes, grapes, and other such things, there is always danger during severe weather of damage due to breakage. A single hailstorm has been known to do £20,000 worth of damage to glasshouses alone, in addition

to which, tens of thousands of tender plants perished at the time from exposure Every market gardener should guard against loss from this source—and it is a more frequent danger than is customarily imagined—by insuring his glass house against damage by the weather Several companies will take such risks at a moderate premium, and one in particular specialises in them

When starting in business, the young market gardener should be careful to ascertain that he is properly rated as, if his holding is of any size such rates will form a considerable item in his profit and loss account Market gardens are only to be rated at one fourth of the amount in the pound which is payable for a dwelling house—that is as far as the general urban district rate is concerned For a Poor

garden, and the return that may be expected from each crop.

The table given below has, however, been carefully prepared with a view to showing the average returns which may be expected from land carrying the various vegetable crops, and will, at all events, be of assistance to the novice who is in doubt as to whether he is managing his market garden in an economical manner

In the item "cost of cultivation" in the table no provision has been made for the cost of manuring Here, again, no hard and fast rule can be laid down Where plenty of natural manure is obtainable, the use of much chemical or artificial manure is not recommended In most cases, however, the soil of market gardens needs a stimulant

AVERAGE YIELD OF MARKET LAND, COST OF CULTIVATION AND MARKET PRICES

	Average yield per acre	Cost of cultivation per acre	Average market price
Artichoke (Globe)	1[illegible]000 heads	Approximately same as cabbage	1s [illegible]d per doz
Artichoke (Jerusalem)	[illegible]0 bushels	Approximately same as potato	2s 6d per bushel
Asparagus	[illegible] cwt	Varies widely	1s to [illegible]s per bundle (100 shoots)
Beans (broad)	120 bushels	Varies widely	[illegible]s 6d per bushel
Beans (kidney)	[illegible]0 bushels	Varies widely	[illegible]s per bushel
Beetroot	3[illegible]0 bushels	24s per acre	[illegible]d to 2s per doz
Broccoli	8 to 10 tons	Same as for cabbage	10s per crate of 6 doz
Brussels sprouts	1[illegible]0 bushels	From [illegible]0s to [illegible]s per acre	[illegible]s per bushel
Cabbage	10 000 heads	[illegible]4s to [illegible]8s per acre	1s per doz
Carrots	[illegible]00 bunches	70s per acre	3s 6d per doz bunches
Cauliflower	1[illegible] to [illegible]0 [illegible]	3[illegible]s per acre	[illegible]s per doz
Celery	1[illegible] 000 heads	£4 to £[illegible]	1s [illegible]d per doz heads
Cucumber	[illegible] 000 from 100 ft house	£2[illegible] per house	[illegible]s per doz
Herbs (various)	1 ton (when dried)	Varies widely	[illegible]0s per cwt
Horseradish	10 000 bundles	[illegible]8s per acre	1s [illegible]d per bundle of [illegible] roots
Leeks	1[illegible] 000 bundles	£6 per acre	2s per doz bunches
Lettuce	[illegible]000 per acre	Varies greatly	6d to 1s 6d per doz
Mushrooms	1[illegible] cwt per 100 yd run	£17 per 100 yd (ridge bed)	[illegible]d per lb
Mustard and cress	This crop is grown in	many varying ways	1s per doz punnets
Onion	400 bushels	£6 10s per acre	[illegible]s [illegible]d per bushel
Parsnip	[illegible]00 bushels	70s per acre	2s 6d per bushel
Peas	1[illegible]0 bushels	Varies greatly	2s per bushel
Potatoes	[illegible] tons	[illegible]8s to [illegible]0s	£[illegible] 10s per ton
Savoy		Same as for cabbage	
Seakale	Varies greatly	Varies greatly	1s per 2 lb punnet
Spinach	4[illegible]0 bushels	As for cabbage	2s to 3s per bushel
Tomatoes	3 lb per plant	Varies greatly	3d to 4d per lb
Turnips	[illegible]00 bushels	40s per acre	4s per doz bunches
Vegetable marrow	1[illegible]00 doz	20s to 2[illegible]s per acre	1s [illegible]d per doz

rate they are liable for half the amount payable for a dwelling house but buildings thereon such as greenhouses, are liable for the full amount It may be well to state here that according to the Market Gardeners Compensation Act a market garden is "a holding wholly or partially cultivated for growing produce for market"—that is to say the crops grown on such land must be for market purposes only A private individual who has a very large garden, and disposes of certain surplus fruit and vegetables in the markets is not a market gardener within the meaning of the Act and his garden is liable to be rated at the full amount It is always well to see that the rates are properly adjusted at the commencement of the tenancy as when once a payment has been made on a higher scale it is a long and tedious process to get either a reassessment or a refund

It is, of course, impossible to lay down any hard and fast rule that will apply to the whole of the country as to the cost of maintaining a market

of some kind and the following little table gives particulars of those which are most economical

Manure	Quantity per acre	Cost
Basic slag	3 cwt	£2 per ton
Dissolved bones	[illegible] cwt	£4 10s "
Guano	1 cwt	£11 "
Nitrate of soda	1 cwt	£8 "
Sulphate of ammonia	1 cwt	£9 "
Sulphate of potash	1[illegible] cwt	£6 "

Any of these manures are suitable for market garden crops with the exception of sulphate of ammonia and nitrate of soda, neither of which is it desirable to apply to peas or beans A very cheap and effective manure for potatoes and onions is ordinary soot used at the rate of three dozen bushels per acre In the neighbourhood of a town this can usually be obtained at a few pence per bushel, rarely more than sixpence

GARDENING *concluded*

FIRE BRIGADE WORK

The Routine of the Fireman's Duties and Conditions of Work
Fire Engines and Fire Escapes   Fire Prevention Devices

from page 6723

By JOHN HENRY WHILE

THE profession of a fireman offers a wide field for activity and energy, and also affords scope for inventive genius. A young man desiring to become a fireman, a member of a trained, skilled, and well disciplined force, must start with the determination to be efficient in his work, and to study it in both theory and practice in order to be able to work all appliances which will come under his charge to the best advantage. In the following description of the training and work of firemen the procedure and system of the London Fire Brigade, as being the premier organisation of its kind in the world, have been taken as the basis upon which the subject should be studied in theory. Practical training, work, and experience are, of course, the essentials to enable a fireman to rise high in his profession.

Selection of Candidates. The system of appointing men as members of a trained fire brigade is practically the same in all large towns, the Chief Officer seeing all candidates at the principal station. In London, until quite recently, it was necessary that candidates for the appointment of firemen should be seamen, but this rule has to some extent been relaxed in recent years, although a young man fresh from the sea with clean discharge papers has a decidedly better chance of acceptance than a candidate who has been employed in more sedentary work. The men must be under thirty years of age, must measure at least 37 in. round the chest, and should be at least 5 ft. 5 in. in height. They must be men of general intelligence, and able to read and write.

The Man's "Pedigree" and Strength. The first thing the candidate is asked to do is to produce his birth certificate and his discharge papers, or testimonials as to character, service, etc. These are carefully scanned, and if they are satisfactory his height and chest measurement are taken, and he is called upon to prove his strength by raising a fire escape single-handed with the tackle reversed. The rope or fall of a fire escape tackle is 20 fathoms, or 120 ft. in length. The escape is laid on the ground rather below the horizontal position, and a tackle is attached to the carriage end of the machine and to a ring in the ground. The candidate stands on the levers of the escape, and, hauling at the tackle, has to pull the machine up from the horizontal almost to the perpendicular until the lever wheels rest upon the ground. When a man on the carriage lever is pulling up the machine with the tackle reversed, the initial pull is 240 lb., and the fixed strain when he is not pulling is 70 lb. When the machine comes to an angle of 45° the pull is 200 lb., and the fixed strain 70 lb., and this gradually diminishes until the hind wheels touch the ground.

Medical Examination. This ordeal having been satisfactorily passed, and the candidate having been approved by the Chief Officer as stout, strong, healthy looking, intelligent, and in all other respects apparently eligible, he is sent for medical examination to the surgeon appointed for the purpose. Inasmuch as service in a fire brigade requires all the energies of a man, it is imperative that only such men should be appointed as are able to pass the surgeon satisfactorily after having gone through the very severe test described. The surgeon, as he thinks fit, either rejects or passes the man, in each case giving a certificate. The certificate given in the case of an approved man takes the following form: "This is to certify that I have examined A. B., and believe him to be free from disease and well suited for the situation of a fireman in the London Fire Brigade."

Probation. These preliminaries settled, the candidate becomes a probationary fireman, and is drafted into the drill class among other men undergoing instruction. In London his course of instruction is carried out at the fine headquarters at Winchester House, Southwark Bridge Road, where he lives for the first three months of his life as a fireman.

A Fireman's Kit. The first morning after the candidate joins he is introduced to his future companions of the drill class, and receives his kit. This consists of three pairs of top boots for fire purposes, three pairs of trousers, three cloth tunics, two jumpers for light wear, three caps, a helmet, belt, axe, spanner, and a pair of shoes for gymnasium purposes. He is found quarters in the drill class block, and messes with his future comrades. He is supplied with a mattress, palliasse, three blankets, and a pillow, but has to find his own sheets and pillow slips. His drill commences from the first day he joins, and he has to complete three months in the drill class from the time of joining. If it is necessary to send him to an out-station before the time has elapsed, he has to return to Southwark and complete the period of drill.

Syllabus of Drill. The drill class of the London Fire Brigade is split up into two parts, the theoretical and the practical sections. For both sections there are two syllabuses of instruction, which are worked in alternate weeks in order to make some change in the routine. The men under instruction, it should be said, are under two instructors, with a station officer in charge. In all cases the bells are rung at a quarter to seven o'clock, and the day's work is opened by physical exercise with Indian clubs and fire ladders. An hour is devoted to cleaning the dormitories, etc. From eight o'clock until nine the men are engaged in breakfast, bed making, and so on, and from nine o'clock to half past nine in cleaning the appliances. There is a stand easy from 9.30 to 9.45, and then the actual work of the day commences.

Theoretical Instruction. The syllabus of work for the theoretical section may be set out in detail day by day. It is as follows:

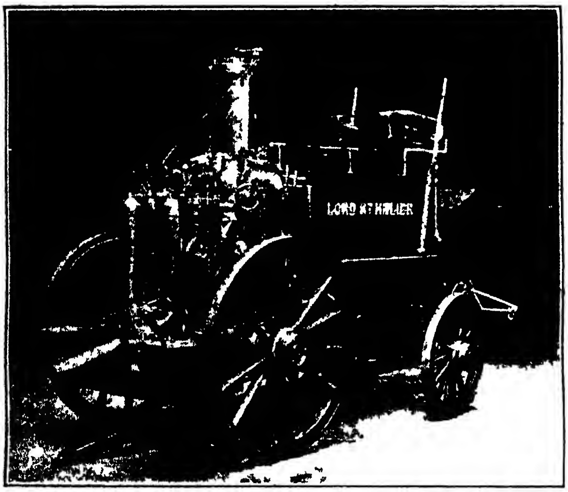
Monday. The men are lectured for three quarters of an hour on the organisation of the brigade and the duties of a fireman. The clothing and general surroundings of the watch room are inspected. An explanation of the nature and use of the helmet, axe, spanner, and gear generally is given, and the instructor adds hints as to the mending and general care of the London County Council clothing. Two

hours are allowed for dinner. In the afternoon, the instructor gives a general explanation of all gear carried on the engines, the method of stowing it, and the different screws and couplings used in the brigade.

Tuesday After physical drill, the instructor gives lecture No 2, on the mobilisation of the brigade, and the systems of fire alarms and communication by telephone and electric bells He also deals with the use of long and short lines knotting, hitches etc, and explains methods of rescue by means of lines In the afternoon instruction is given on London water supply mains service pipes supply pipes fire plugs cocks and hydrants the men receiving a thorough insight into the way in which London is supplied with water for fire purposes

Wednesday After the usual drill the members of the theoretical class assist to prepare for the general display which is always given to the public at the Southwark headquarters on Wednesdays and are instructed in jumping into sheets and in methods of rescue work with lines In the afternoon they assist with the general drill

Thursdays The instructor delivers lecture No 3



1 300 GALLONS EXPANSION STEAMER
(Shand Mason & Co Ltd)

on fires, methods of dealing with chimney fires and the use of large and small canvas dams at fires In the afternoon the men are instructed in the use of first aid appliances and receive an explanation of the methods of using branches nozzles hose suctions, and couplings together with a description of the manufacture and method of making up lines of hose

Friday After physical drill the men are instructed in bringing down insensible persons and in the use of the smoke helmet In the afternoon they take part in wet drill with a steamer and in the evening clean out all the dormitories

Saturday After the general work of assisting in cleaning all gear and the headquarters generally, the men 'stand easy'

Alternative Syllabus. The alternative syllabus of the theoretical class, which is carried into effect on the second and fourth weeks in each month, includes the usual routine of physical drill every morning. On *Mondays* the men receive instruction in picking up and bringing down insensible persons, and take part in bucket, hand-pump, and manual drill. In the afternoons, they carry out scaling and hook ladder drill, and receive explanations of the fire alarm system, and of the proper methods of forwarding 'calls,' 'stops,' etc, in regard to actual fires

On *Tuesdays* they enter upon hose cart drill with hydrants and stand pipes and in the afternoon take part in horse escape drill, and in exercise rescue work

On *Wednesdays* the work is practically the same as that given under Theoretical Instruction

On *Thursdays* the men receive an explanation of the use of the manual engine and of first aid appliances and undergo in the afternoon watch-room instruction and an explanation of the methods of carrying out duties and watches at street stations and in fire escape boxes

On *Fridays* they are drilled in the work of carrying down insensible persons restoring life by artificial methods and in escape work Friday afternoons are devoted to general cleaning up work

The Practical Class. From the theoretical class the novices under instruction are promoted to the practical class where the early morning routine is the same The first week's syllabus of instruction apart from this routine consists briefly stated, of the following programme of work

Monday The men are instructed in the method of picking up insensible persons they prepare for and carry out wet drill with a steamer In the afternoon they receive instruction in testing and repairing hose undergo practice in rendering first aid to the injured drill with the horsed escape are instructed in the use of escapes and ladders in cases of emergency, and carry on rescue work with lines They pack up at four o'clock The men are divided into three watches of leave, and those on leave are at liberty until 1 a m, while the others engage in station and other duty

Tuesday The members of the practical class are exercised with jumping sheets and in hose cart drill in addition to horsed escape and manual drill In the afternoon they are instructed in the geography of the London County Council area, the mobilisation of the Brigade and the duties of firemen generally

Wednesday The curriculum includes much of the previous drill and also extends to the use of smoke helmets scaling ladders as used in climbing over walls and roofs at actual fires hand pump drill rescue by lines long ladder drill, and preparations for the general drill The men construct large canvas dams in the drill yard and fill them for the purposes of the public drill

Thursday The same drill with variations, is carried out and in the afternoon all appliances are washed off, tested, oiled and cleaned generally

Friday The men receive instruction in the stables harnessing horses, and are taught to assist the coachmen in getting them away quickly Later on they practice carrying insensible people off the roof, and take part in smoke helmet and hose cart drill combined All dormitories are cleaned out in the evening, and on all Tuesday and Friday nights ambulance classes are carried out

Practical Class. The alternative syllabus for the practical classes includes, on Mondays, a lecture on the duties of firemen in regard to calls to fires and chimney fires, and to the methods of work

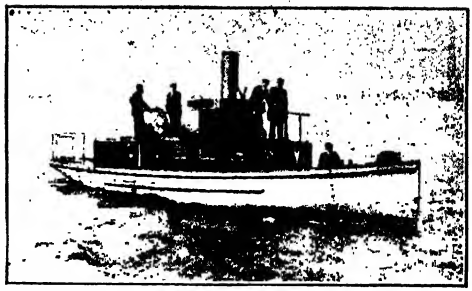
at actual fires. In the afternoon, the ladders and lines used in the Brigade are tested, and wet drills with a steamer and horsed escape, manual, and scaling ladder drills, are carried out. On Tuesdays, the curriculum includes horsed escape, hose-cart, and escape drill, the use of first aid appliances, and instruction in the organisation of the Brigade, watch-room routine, and the methods of keeping an "occurrence book." On Wednesday, the ordinary routine of the public drill day is carried out. On Thursdays, the chief duty is to test, wash, and clean all appliances, while on Fridays the work includes physical drill, instruction in stables, practice in carrying down insensible persons, hook-ladder and escape drill, and wet drill with the steamer. The bedrooms and mess-rooms are scrubbed out, and at night the ambulance class is held.

When a period of three months of this arduous and continuous drill has been carried out, the men are rightly considered to have become proficient in their new calling, and, as vacancies occur, are drafted out to different stations in various districts of London.

Duties of Firemen. The general duties of a fireman are to reside at the station to which he is appointed, to be at all times within hail, and available for any duty, unless specially booked otherwise; to take his turn in watching at the station, taking charge of escapes, attending fires, and all other duties, when ordered by his superiors; to assist in the cleaning and other work at the station, relieving the men on duty for meals, etc; to be civil and respectful in his demeanour, and clean in appearance; to perform all duties entrusted to him in a prompt and efficient manner; to hold himself in readiness for any duty he may be called upon by his superiors to perform; to obey implicitly all orders of his superiors, and to exact the strictest obedience and respect from those under him; to study and otherwise endeavour to qualify himself to perform the duties of his superiors when called upon to do so.

Special Duties. There are four distinct classes of firemen, apart from officers—namely, first, second, third, and fourth—and the above duties, as general rules, apply equally to them all. It happens, however, that in the carrying out of the laborious work of a fire brigade, there are many duties requiring special qualifications and capacities, and these naturally fall in most cases to the lot of those who have served longest and worked hardest. These duties consist of taking charge of the floating steam-engines and the land steam-engines, mechanical work at the factory, repairing engines, and so forth, drilling and instructing the young hands, keeping the accounts, books, and records of the establishment, and preparing reports, etc. It is therefore incumbent on all ranks to study and understand, not only their ordinary duties, but also those of their superiors, in order that, when called upon, they may be found equal to the performance of any duty devolving upon them.

General Working. Every man is always supposed to be on duty, for duty, on leave, sick, or suspended. Those on duty are in full dress, with the exception of their helmets. Those for duty are ready to turn out at a moment's notice, and are therefore not permitted to go outside the station, except within view. An officer in charge of the station has power to grant leave to any man of his own station up to eight hours; a Superintendent has power to grant leave up to 48 hours; and any leave which exceeds 48 hours must be granted by the Chief Officer.



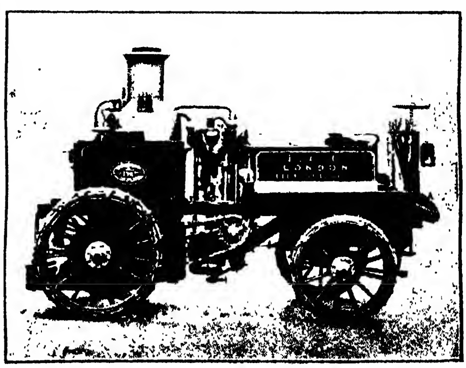
2. RIVER FIRE FLOAT
(Armstrong, Whitworth & Co., Ltd.)

When the men under instruction are drafted out, as already described, they are classified as fourth-class firemen, and remain in that position for three years. At the expiration of that time, on the recommendation of their officer, they are promoted to the rank of third-class firemen. After that, promotion is by merit, as proved after examination.

Steam Class Drill. In due course, the third-class fireman returns to headquarters to undergo a course in steam drill, which will enable him to take charge of a steam fire-engine. Later on, if he succeeds in passing an educational examination, he rises to the rank of second-class fireman, every promotion carrying with it increased pay. Promotion to the first class is obtained by the passing of a special examination, which includes writing, arithmetic, the making up a pay-sheet, the geography of the Brigade, and such miscellaneous subjects as may be selected by the education board, which is drawn from the officers of the force.

Higher Promotion. As time goes on, and vacancies occur, men passing special examinations become sub-officers, and at the end of 15 years of completed service a fireman in the ranks has a fair chance of becoming a station officer, and of taking charge of one of the fire stations which are scattered all over the metropolis. The next rank is that of District Officer, and finally a member of the London Fire Brigade has a chance of rising to the status of Superintendent, and of taking charge of one of the six districts into which London is divided for fire brigade purposes.

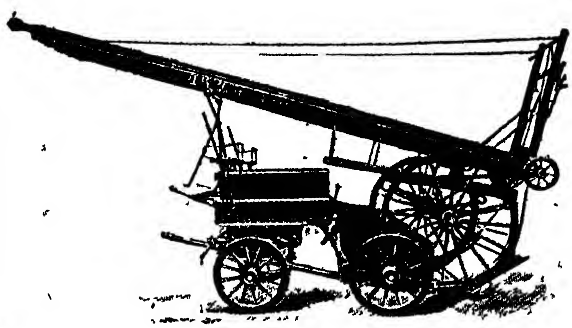
Fire-engines and their Management. The plant with which a fire brigade has to deal naturally varies in extent, according to the size of the city or town which it has to protect. In London the appliances used are of a very varied



3. MOTOR "FIRE KING" (Merryweather)

character in order to suit the different localities which have to be protected, the City and Central London districts requiring more powerful appliances and longer fire ladders than are requisite for service in suburban districts. The plant may be summarised as consisting of hose-carts, manual engines, steam fire-engines [1], motor fire-engines [3], horsed escapes for life-saving purposes, extension ladders for fire extinguishing purposes, chemical first-aid appliances (now carried on all horsed escapes), hose, coal, and oil vans, fire-engines on barges, and a river float [2] for dealing with riverside fires. Fire-engines, it may be briefly said, are of various kinds. Some are fixed in walls or stationary places, and cannot be moved at all, some are fixed in ships or barges on the water, and others in carriages on land; some are in themselves movable, and, whether on fixed or movable foundations, can be mounted or dismounted at pleasure. Some are worked by water, some by steam, some by manual power, and some by chemicals.

Hose-carts. A hose cart is a light box built on a pair of wheels to carry three 100-ft lengths of hose, without the inconvenient addition of a reel. The box has a capacity of 13 cubic ft, of which 10 cubic ft. are for the hose and three for the tools. The hose can be laid out from a hose-cart as from a reel, and when not in use is protected from the weather and kept quite clean. A hose-cart, when empty, weighs $2\frac{1}{2}$ cwt., and when full, $5\frac{1}{2}$ cwt. and it can easily be run to a fire by one man.



4 HORSED HOSE AND LADDER TRUCK
(Bayleys, Ltd)

A Six-inch Manual Fire-engine. Although manual engines have gone out of vogue in London, they are still extant in certain local districts of the metropolis, and a great number are in use by brigades all over the United Kingdom. A 6-in. manual consists of a pair of single acting force pumps, with an inlet pipe, four valves, an air vessel, two delivery pipes, and a rocking shaft, mounted on a carriage with four wheels, and worked by levers, which are attached to a spindle passing through bearings in the carriage frame. It is, therefore, so far a fixture that the pumps cannot be separated from the carriage without delay and difficulty, but the whole machine, including the travelling and working parts, is movable, and is made as light and portable as is consistent with the necessary strength.

The sole-plate, on which the works are fixed, is a box or bed of cast iron, comprising the bottom, sides, and part of the top of two pairs of valve-boxes, one pair behind and one in front, flanges to receive the corresponding flanges of the cylinders, and the bottom and sides of two waterways, one at each side. The waterways begin at the hind or stern end of the valve-box, where they are separated and pass forward, each through one part of the hind valve-box, underneath the cylinder at the same side, and through the front valve-box, in front of which they come together again, thus forming two curved channels, starting from the same point behind, and joining again in front. The suction-valves, two in number, are made of gunmetal, and are of the kind commonly known as hinged inclined metallic valves. These valves are self-acting—that is, they are not fastened by means of connecting rods or otherwise to any of the moving parts, and consequently are not set in motion by any direct action of machinery, as is the case with mechanical valves, but are opened by the fluid, whether air, water, or other substance, which is passed through the pump, and when this pressure ceases, close of their own accord by gravitation. The lift of these valves is $1\frac{1}{4}$ in., and the area of the opening is 4.9 sq. in. The force necessary to open them is a pressure of ·254 lb., or, in round numbers, about $\frac{1}{4}$ lb. on the square inch.

The engine has a pair of cylinders on opposite sides of a rocking shaft, with pistons driven by a reciprocating movement of the arms of the working beam. The united capacity of the two pumps, or the quantity of water received and discharged on a stroke of the engine is 452.38 cubic in., or 1.63 gal. In round numbers, the capacity of the engine is a little over $1\frac{1}{2}$ gal. When the engine is in proper order, and worked at reasonable speed, the quantities of water delivered are in exact proportion to the number of strokes made, without reference to the force applied, the speed at which the handles are worked, the pressure, or any other circumstance. The engine can be worked to the best advantage by thirty men, and the harder they work the greater will be the result but the quantities of water delivered are measured not by the amount of their labour, but by the actual result made good in the number of strokes. The proper crew for this engine consists of four firemen and a coachman, and their weight in full uniform may be taken at an average of about $7\frac{1}{2}$ cwt. The total weight of this engine when proceeding to a fire may be estimated as follows: engine, 18 cwt., gear, $6\frac{1}{2}$ cwt., men, $7\frac{1}{2}$ cwt.; total, 32 cwt., or, in round numbers, between $1\frac{1}{2}$ tons and $1\frac{3}{4}$ tons.

Steam Fire-engines. The fire brigade experts of London and other great towns have found that the best steam-worked pumps, or steam fire-engines, are those which are of simple construction, the parts of which are the most visible and accessible, and it is hardly necessary to point out that in principle there is no difference in the action of a pump, whether the motive-power be produced by men, by water, by steam, or in any other way. Pumps driven by steam are, in practice, run faster than those driven by hand power, and consequently the valves are generally arranged to work more quickly. For the sake of silence, as well as to avoid the risk arising from constant blows, they are generally made either of some soft material or of metal mounted with a soft facing of leather or rubber. Occasionally absurd powers are attributed to steam fire-engines by ignorant or interested

persons, and in that respect it is necessary only to say that the real capacities of the machine can be tested by any engineer in the ordinary way by having their horse power indicated, and that the equivalent man power can be obtained by multiplying the horse power by 5. Where steam fire engines are used there is a choice of only two courses with respect to their getting to work. One is to wait fourteen minutes while raising steam, and the other is to keep the water boiling in the engine house, so that the steamer, when called out, will have a sufficient working pressure of steam in about three minutes.

Manipulating the Fire-engine. Every boiler of the pattern at present in use is fitted with a glass water gauge of which the bottom cock is on a level with the upper tube plate or crown of the fire box, and the top cock 12 in. higher. The glass is protected by guard brasses fastened at the top and bottom with sheet brass clamps, and the guards are marked so as to show the inches above the crown plate. There are 7½ in. of the glass visible between the clamps. Each boiler has three gauge cocks, the bottom one being 2 in. above the crown plate, the middle one 3 in. above the bottom, or 5 in. above the crown plate, and the upper 3 in. above the middle, or 8 in. above the crown plate. The bottom gauge cock should always show water, the top gauge cock should always show steam, and the middle gauge cock should generally show both water and steam.

Steam duties on board the floating engines[2] and in charge of the land steamers comprise work which requires a large amount of special explanation, which is given by responsible officers, and can be understood only after long study and explanation. No man receives a charge of this kind until he has first proved his professional qualifications for it. The general instructions issued in the London Fire Brigade for working a land steam fire engine, it may be stated, include the following.

1. The boiler of this engine is to be worked at a pressure not exceeding 120 lb. on the square inch.

2. The safety valve is not to be screwed down to more than 100 lb., and the engineer must occasionally raise it by hand or otherwise both when getting up steam and when at work.

3. In order to keep this valve free, and to prevent it sticking, he is to ease up the spring, and to remove the whole pressure from it when not required, except sufficient to keep the lever and spring balance from shaking while the engine is travelling.

(4) Whenever the work admits of it the engineer is occasionally to fill his boiler with water as high as possible without allowing it to prime, and then blow off from all the cocks, including the gauge cocks, using only one at a time. This is the best precaution against scale or scum, and an intelligent engineer will find many opportunities of adopting it without interfering with the necessary work of his engine.

(5) In addition to this, the boiler is to be altogether blown out, and washed out occasionally.

(6) The engineer must be careful to see that no soot is allowed to accumulate on the shelf or tube plates of the boiler, as this would reduce its steaming power considerably.

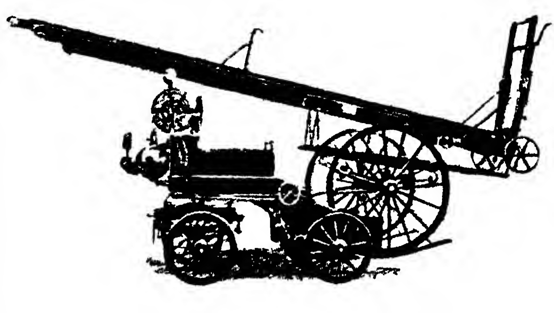
(7) The engineer is held responsible that the water in the boiler is always kept in sight in the gauge glass, whenever the fire is alight, and in case of any accident such as the failure of the feeding apparatus, rendering this impossible, he is immediately to draw his fire.

(8) A sufficient quantity of water should always be kept in the feed vessel for supplying the boiler when the engine is not at work.

(9) It being exceedingly dangerous to pour cold water on hot boiler plate, the engineer is desired to be particularly cautious about putting cold water into the fire box, and in case it becomes absolutely necessary to do so he is to pour it on the fire bars only, and not on the inner shell of the boiler or the tube plates.

(10) After the suction pipe has been taken out of the water the engine should be run round for a few strokes in order to blow the remaining water out of the pump.

(11) On his return from a fire the engineer is to enter in the book kept for that purpose the following particulars as far as he is able—namely, time at work, number of revolutions, quantity of water delivered, and any other circumstances which appear worthy of remark, such as the length of hose, number of deliveries, height of branch above engine, etc.



5. CHEMICAL EXTENSION LADDER

Hose. The laying out and handling of the flexible pipes or hose which convey water have much to do with the most active part of a fireman's work. The pipes are chiefly of two kinds, the one known as suction pipes, which convey the water from the reservoir or hydrant to the pumps, the other delivery pipes, or hose which convey the water from the pumps to the fire.

Suction pipes are made of leather stretched over a metal spiral, which prevents them from collapsing when a vacuum is formed inside. Suction pipes are of three sizes, and are carried on the engines in short pieces. They are mounted with couplings of an exactly uniform pattern, and can be used singly or with several joined together according to their respective size.

Delivery pipes or hose are made of canvas or leather. The hose at present almost exclusively used by the London Fire Brigade is of canvas, and is for the most part lined with indiarubber. The canvas pipe is made of the best flax, carefully woven, with about 10 turns to the inch in the weft or circular thread, and about 15 threads to the inch in the warp or longitudinal thread. A length of canvas seamless rubber lined hose as delivered by the various manufacturers for the use of the London Fire Brigade, has an internal diameter of 2¾ in., so as to take a coupling with a 2 in. waterway, and is almost invariably 100 ft. in length. Each length of hose is provided with a leather strap, 3 ft. 3 in. long and

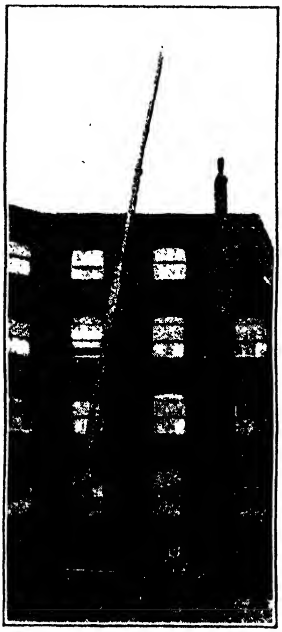
1¼ in. wide, fitted with a suitable tinned-iron roller buckle, riveted to it, and a collar to slide along the hose. The rivets and washers are of the best wrought copper, properly tinned to prevent verdigris.

Chemical Engines, or "First Aid" Appliances. The chemical engine consists of a copper cylinder holding 24 gallons of water. This is connected to a compressed air cylinder by a copper tube fitted with a suitable valve. The compressed air, on being admitted to the copper cylinder, drives the water out through an indiarubber hose which terminates in a stopcock jet. The hose is wound round a reel, and the water enters it from the centre of the reel, so that any length can be run out, and no connecting up is required. A length of 50 ft. of 1 in. hose is usually supplied, and it is carried already filled with water.

The copper cylinder is fitted with a safety valve and pressure gauge, so that the screw-down valve which lets in the compressed air can be opened or closed to the correct extent. On arrival at the fire a man takes the jet in his hand and runs with it to the seat of the fire, the hose winding off the reel as he runs. The valve is open and the compressed air is let in. All the man has to do on reaching the fire is to turn on the stopcock of the jet. He then has a powerful jet of water which will carry 50 ft. to 60 ft., and which flows for about eight minutes.

Should a further flow be required, there is a connection fitted to the copper cylinder to take the standard 2½ in. coupling, so that the water from the main can be brought through the indiarubber hose.

Fire-escapes. Fire-escapes are of various sizes and patterns, and differ considerably in certain small matters of arrangement of parts, and so forth, but the best of those in use are for the most part similar in all the essential points. An ordinary fire-escape is a ladder mounted on a carriage with four wheels, two high and two low. When all the wheels are on the ground the escape stands at an angle of about 25° from the perpendicular, and would fall over unless supported by being pitched against a wall, or balanced by a pressure at the end of the folding lever attached to the carriage. The general dimensions on an ordinary hand fire-escape are as follows: main ladder, 50 ft. 3 in.; fly ladder, 19 ft. 4 in.; first-floor ladder, 16 ft. 3 in.; supplementary ladder, 10 ft. 4 in. The modern appliance, now in use in London, is the horsed escape [4], and in this case the escape is carried on a van, which is drawn by two horses, and is turned out from the station and galloped to the scene on the first ringing of any fire alarm signal into the depôt. In the case of these escapes, the ladders are to a certain extent telescopic, and they are supplemented by hook ladders, with which the men mount from window to window for rescue work. They also carry hose.



6. 70-FT. TURNTABLE FIRE LADDER
(Shand, Mason & Co., Ltd.)

A fire-escape when properly pitched may safely carry a man on almost every round, and a fly ladder, when unshipped and standing on the ground, may carry some eight or ten men; but a fly ladder when thrown, ought not to have more than about three men on it at a time, as the whole weight comes on a single spot of the main ladder. In all ladders it is necessary that great care should be taken to distribute the weight, and not to allow it to rest on one spot or one portion. Thus, for instance, a ladder 28 ft. long may carry one man on every round, or 28 men in all, whereas six men at some one spot may instantly break it.

Firemen must always use the greatest discretion in leaving their escapes, even for a moment. There are cases in which a fireman is justified in running away with a hand pump, or one of the small ladders, as, for instance, when a fire is discovered within a few feet of his post and within sight, but even under these circumstances he ought to be very cautious.

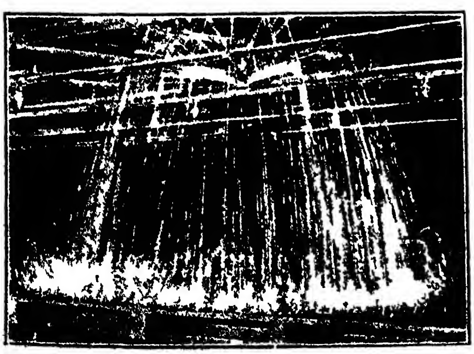
Life Saving. The all-important work of saving life from fire includes many and various branches. If all houses were exactly alike, with the same contents, the same number of inmates, and those all of the same ages, the same conditions of activity or helplessness, and occupying the same parts of the houses, it might be possible to lay down precise rules for their rescue; but when it is remembered not only that the circumstances are never alike in any two cases, but that the time of the "call" being sent away from the house on fire, the time of its being received at the escape station, and the time of the arrival of the escape all depend upon a number of contingencies which differ most materially, and can never in any way be foreseen, it will at once be obvious that in almost all cases everything depends on the quickness, presence of mind, and personal activity of the fireman in charge. To do his work properly, a fireman must be strong, quick, fearless, and intelligent; but above all things, he must be resolute.

Extension Ladders. For purposes of dealing with fires in lofty warehouses, extending ladders on a telescopic principle are largely used in the London Fire Brigade, and the most up-to-date appliance is a ladder which extends itself automatically by the force of chemicals [5]. In the ordinary long ladders the appliances are usually extended by means of a screw-handle. Turntable ladders are also used by the Brigade [6].

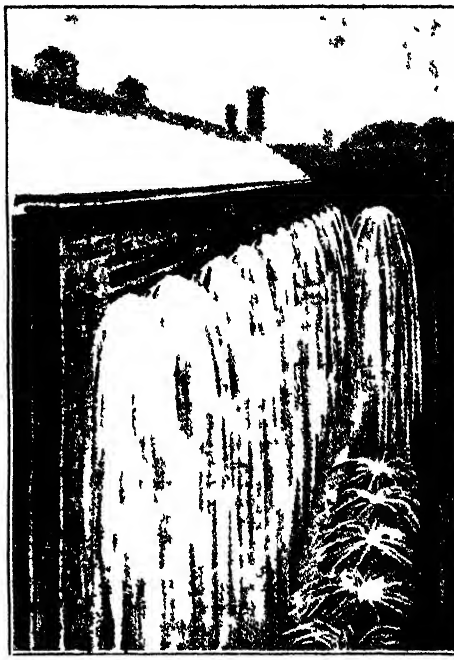
The Actual Work of the Brigade. The manner in which the London Fire Brigade deals with actual fires depends, naturally, upon the character and extent of the outbreak. There are three ways in which the firemen receive "calls" to fires—either verbally from civilians or policemen, by the ringing of fire-alarm signals, or by messages over the telephone through the Telephone Exchange. In any case, the station which receives the first "call" responds by sending out, first, a horsed escape, and then a steamer. The particulars of the first "call" are instantly telephoned by the duty-man, who remains at the station, to the district headquarters, and from that centre the firemen at the other stations nearest to the fire are ordered to proceed with their steamers and other appliances.

Early Work at the Fire. The first arrivals at the fire immediately proceed with the task of extinction and rescue work, if there be any necessary, and upon the officer in charge devolves the responsibility of communicating immediately to his district headquarters a message describing the character of the outbreak. This is done from the nearest fire alarm post by telephone, for practically all the fire alarm posts in London are now telephone stations as well. There are three code messages which are used, and which indicate whether the fire is a slight fire, a serious fire or a very dangerous fire. If the outbreak is one which can be dealt with by the appliances in hand the words "home call" are telephoned to the district depot, and no more appliances are sent on. Should the fire be a serious one, and spreading, the message "district call" is transmitted and altogether a force of about seventy firemen, a dozen steamers, long ladders, and other appliances are despatched from the different fire stations in the particular district in which the fire is raging. The superintendent of the district proceeds to the scene to direct operations, and every steamer, as it arrives with full steam up, begins to pump water on the burning building. In the event of the fire being a very serious one, the message "brigade call" for the particular locality in which the conflagration is raging is telephoned to the Southwark headquarters, and then every district in London is called upon to render assistance. A score of steamers are hastily concentrated at the scene, the river floats are ordered to proceed from their moorings if the fire is anywhere near the river side, huge canvas dams are erected for the engines to pump water from, and within a marvellously short space of time powerful land steamers will be busy in every street surrounding the property involved throwing thousands upon thousands of gallons of water upon the flames. The efforts of the Brigade will probably be directed by the Chief Officer and his three Divisional Officers, assisted by the Superintendent of the district, and while the fire continues to rage coal and oil vans will be continuously running between the scene of the fire and the local headquarters carrying fuel for the steamers, some of which now work with petrol. When the fire is "in hand" a message is despatched giving the code word "stop" and stating that no more help is required, while later on a brief summary message as to the extent of the damage is forwarded to headquarters.

Outside Fire Appliances. Apart from the different devices and appliances which the London



8. SPRINKLERS INSIDE A BUILDING



7. SPRINKLERS IN ACTION OUTSIDE A BUILDING
(Mather & Platt Ltd.)

Brigade uses in its work of coping with fire are many useful inventions of which large private firms avail themselves for the purpose of disclosing automatically an outbreak of fire and of checking it in its incipient stages. These devices include automatic fire alarms which are arranged so that when the temperature of a room, office, or warehouse floor rises to a certain degree a melting takes place, the immediate result of which is to ring alarm bells outside the building, or in connection with one system into the central office some distance away, from which the fire alarm is given to the fire brigade.

Automatic sprinklers are arranged on a similar system, and when the temperature rises to a certain degree in a room or office in which the sprinklers are fitted a wax connection is melted which releases a force of water from fitted pipes. The water in its turn acts upon a sprinkler, and the goods beneath this arrangement are presently deluged with water [8]. At least one large building in the City is fitted with a system of sprinklers [7] which, when in operation, makes a complete curtain of water outside the building and on every side of it, the idea being that should a fire break out in an adjoining warehouse the sprinklers could be set to work and would act as a shield to the warehouse in which the device is fitted.

Progress and Improvement. In every branch of fire brigade work there is so much scope for improvement that it would be a wise man who could prophesy when finality will be reached, and in view of the remarkable advance which has been made even in the last decade in fire extinguishing and life saving appliances, it seems safe to prognosticate that every year will witness further developments and improvements in these all important devices.

FIRE EXTINCTION *concluded*

COMMERCIAL & PERSONAL LAW

Commercial Law—continued. Employers' Liability. Landlord and Tenant. Personal Law. Marriage and Divorce. The Married Woman's Property Act

THERE remains to be given briefly the rules as to delivery, which will be found in Sect. 29, 32, and 34 of the Sale of Goods Act.

Sect. 29.—(1) *Whether it is for the buyer to take possession of the goods or for the seller to send them to the buyer is a question depending in each case on the contract, expressed or implied, between the parties. Apart from any such contract, expressed or implied, the place of delivery is the seller's place of business, if he have one, and if not, his residence, provided that, if the contract be for the sale of specific goods which to the knowledge of the parties when the contract is made are in some other place, then that place is the place of delivery.*

(2) *Where under the contract of sale the seller is bound to send the goods to the buyer, but no time for sending them is fixed, the seller is bound to send them within a reasonable time.*

(3) *Where the goods at the time of sale are in possession of a third person, there is no delivery by seller to buyer unless and until such third person acknowledges to the buyer that he holds the goods on his behalf, provided that nothing in this section shall affect the operation of the issue or transfer of any document of title to goods.*

(4) *Demand or tender of delivery may be treated as ineffectual unless made at a reasonable hour. What is a reasonable hour is a question of fact.*

(5) *Unless otherwise agreed, expenses of and incidental to putting the goods into a deliverable state must be borne by the seller.*

Sect. 32.—(1) *Where, in pursuance of a contract of sale, the seller is authorised or required to send the goods to the buyer, delivery of the goods to a carrier, whether named by the buyer or not, for the purpose of transmission to the buyer, is prima facie deemed to be a delivery of the goods to the buyer.*

(2) *Unless otherwise authorised by the buyer, the seller must make such contract with the carrier on behalf of the buyer as may be reasonable, having regard to the nature of the goods and the other circumstances of the case. If the seller omits so to do, and the goods are lost or damaged in course of transit, the buyer may decline to treat the delivery to the carrier as a delivery to himself, or may hold the seller responsible in damages.*

(3) *Unless otherwise agreed, where goods are sent by the seller to the buyer by a route involving sea transit under circumstances in which it is usual to insure, the seller must give such notice to the buyer as may enable him to insure them during their sea transit, and if the seller fails to do so, the goods shall be deemed to be at his risk during such sea transit.*

Sect. 34.—(2) *Unless otherwise agreed, when the seller tenders delivery of goods to the buyer, he is bound on request to afford the buyer a reasonable opportunity of examining the goods for the purpose of ascertaining whether they are in conformity with the contract.*

Acceptance. And lastly there is the law to *Acceptance:*

Sect. 35.—*The buyer is deemed to have accepted the goods when he intimates to the seller that he has accepted them, or when the goods have been delivered to him, and he does any act in relation to them which is inconsistent with the ownership of the seller, or when, after the lapse of a reasonable time, he retains the goods without intimating to the seller that he has rejected them.*

Sect. 36.—*Unless otherwise agreed, where goods are delivered to the buyer, and he refuses to accept them, having the right so to do, he is not bound to return them to the seller, but it is sufficient if he intimates to the seller that he refuses to accept them.*

We have endeavoured to give the simple rules which the business man should master in the daily course of his affairs. To discuss such matters as stoppage in transition, lien, "rights in rem" and in "personam" would be profitless here, since they correlate some basis of legal training.

Agency. It is still necessary to give a few rules explicatory of the doctrine of *Agency*, and then we can pass on briefly to other parts of the law which deals with a man in his life in the world.

The great distinction in *agency* lies between the agent proper, or particular, and the broker or what we might call the agent general. The agent proper is the nominee of any individual business man to do his business, to sign for him in any particular transaction or series of transactions. Such an agent is in a semi-fiduciary position towards his principal; he may be paid by salary or commission, and face to face with the other side in the transaction he practically *is* his principal. What the latter does through him he does himself. The principal is liable for the agent's negligence or tort or (to a certain extent) dishonesty.

A broker, on the other hand, is a person whose business it is to carry through contracts of sale and purchase of goods which are not his and which he does not buy for himself. He may be the agent both of the vendor and the vendee—indeed usually is. His responsibility to either is not in any way so onerous as though he were the appointed private agent of either. The niceties of the law upon this subject are great, but the business man may content himself with this single broad distinction.

He should realise in all cases where he is interested in transactions carried through by delegated authority whether the delegated authority is that of a private agent of his own or of a general agent or broker. And in the same way the agent should be clear in his own mind whether he is employed by one principal or by more than one. The difference is of vital importance to his status, and to what he can and cannot do. With that broad distinction we must leave the law of sale and purchase and pass on to the next branch of a man's daily life.

The Law of Service. Since every human being of adult years is either a servant or a master, and not infrequently both, it stands to reason that the laws governing employment must be of vital importance to very many. In even the simplest cases questions arise as to how wages should be paid, when are they due, what notice should be given, and the like.

At the outset let it be said at once that a great deal of nonsense has found its way into the heads of ignorant people upon these subjects They imagine that the law will not allow this or will allow that, whatever the arrangement between the individuals Let it be said at once that the policy of our law is to leave as free a hand to individual idiosyncrasies as possible So long as an agreement is not immoral or against public policy or obviously oppressive or obtained by misrepresentation or fraud or duress the law will compel its fulfilment

If A and B agree to become master and servant respectively, with wages paid at uncertain intervals and no notice of termination on either side that is a perfectly good agreement and can be enforced As a rule, however, parties do not care to enter upon eccentric arrangements of this kind Very often in domestic service no written agreements are drawn up, since none are required and then it becomes a matter of interest to state what implied rules of law govern these relations In English domestic service the usage is that in the absence of any express agreement, the wages should be paid monthly and that the service should be terminated by a month's notice on either side In lieu of this a month's wages must be paid or forfeited Of course, gross insubordination upon the part of the servant or drunkenness or immorality or culpable and wilful carelessness justifies the employer to dismiss without any notice and in the same way a servant who is badly treated or starved may leave at once without notice All these points are matter of fact or proof

Summary Dismissal. The cause for summary termination must be a substantial one Carelessness on the part of the servant or unsuitability on the part of the employer would not justify it The wages need not be paid in advance unless there is an agreement to that end But they must be paid when due The employer may make deductions from them for breakages but such deductions must be honest and careful and not capricious The employer is bound to feed his indoor domestic servants and give them proper sleeping accommodation—though there is no real supervision to ensure either of these requirements and in London at any rate, even in the best houses they are often conspicuous by their absence The servant is entitled to reasonable relaxation No employer is entitled to turn a servant into a slave And this relaxation must include leave of absence at stated intervals Every servant has a right to that, and where it is denied the servant is entitled to leave forthwith, and no court in the country would think for a minute of penalising such conduct

If a servant is insubordinate an employer may turn him (or her) out, but the employer will not escape responsibility for any breach of the peace that may ensue If an employer has reason to believe that a servant has secreted some of his property he is not entitled to search the servant's boxes without an order from a magistrate and in any case an employer is never allowed to detain a servant's luggage It may be added that even in cases of summary dismissal a servant is entitled to recover arrears of wages but of course only those accruing, and not any compensation in lieu of notice Domestic servants are now entitled to compensation for injuries, but this does not deprive them of their common law right to recover damages against their employer for culpable negligence resulting in disablement.

Clerks and Workmen. Employees who are not menials—*e g.*, clerks, staffs of banks, etc., governesses and tutors—are usually, in the absence of agreement to the contrary, entitled to a quarter's notice In this respect the usage of any particular calling may have weight with the court provided it can be proved Agreements for employment where the employee agrees not to follow out the same business himself in the same area after leaving are good in law But an agreement not to follow the same business at all anywhere would probably be bad

Workmen come under a class by themselves, and may be defined thus

Workman does not include a domestic or menial servant but means any other person who being a labourer servant in husbandry journeyman, artificer handicraft man miner, or otherwise engaged in manual labour whether under or over twenty one years of age has entered into or works under a contract with an employer whether the contract is made before or after the passing of the Act (38 and 39 Vict cap 90) be expressed or implied oral or in writing and be a contract of service or a contract personally to execute any work or labour

The Truck Acts. The Acts known as the 'Truck Acts' which are now being altered and recodified are directed to a very simple principle Their object is to prevent masters paying their workmen in kind or making deductions from their wages The Truck Act of 1831 forbids the payment of wages in aught but the current coin of the realm No stipulation must be made by the master as to where and when the wages may be spent or how No employer may pay wages in goods nor can he set off against a claim for wages goods supplied by the employer, or supplied by any shop in which he may have an interest Infraction of the provisions of this Act lays the employer open to a heavy fine

In 1887 the former Truck Act which still remains in principle the law of the land was greatly extended, and to a certain extent it was modified Thus, the new Act specifically recognised a contract with a servant in husbandry for giving him food, drink (non intoxicating) a cottage or other allowances *in addition to* money wages as part payment for his services

It is expressly enacted that no employer shall dismiss any workman from his employment because he spends or fails to spend his wages at any particular place

This provision would seem to raise the whole question of how far it is legal for employers to try and place certain places of business (mostly inns and public houses) 'out of bounds' for their employees That such a practice is resorted to in more than one district no one who knows anything of English industrial life will attempt to deny That it is illegal whether from the point of view of the Truck Acts or of the common law of trade interference is less doubtful

Payment in Advance. Whenever, by custom agreement or otherwise, a workman is entitled to receive part of his wages in advance, it is unlawful for the employer to withold such advance, or make any deduction in respect of interest or poundage

It may be worth while turning aside here for an instant to point out that the courts almost invariably require a strict proof of the existence of a custom.

Section 8 of the Truck Act, 1887, enacts that:

No deduction shall be made from a workman's wages for sharpening or repairing tools, except by an agreement which does not form part of the conditions of hiring.

Where articles are made by a person at his own home, or otherwise, without the employment of any person under him except a member of his own family, the shopkeeper or dealer who buys such articles from him must pay him in the current coin and not in kind, under penalty of becoming liable to the fines imposed for infringement of the Act of 1831 (Section 10).

This section only applies to articles under the value of £5, knitted or otherwise, manufactured of wool, worsted, etc.

The factory and mine inspectors enforce the Truck Acts in the factories, mines, and workshops inspected by them.

Fines. Under the Truck Act, 1896, it is enacted that:

An employer shall make no contract with a workman to deduct any sum from his wages by way of fine, unless:

(a) The terms of the contract are contained in a notice kept constantly in a place open to the workman, and in such a position that it may be easily read by him; or the contract is in writing signed by the workman; moreover, the contract must specify the acts or omission in respect of which a fine may be imposed, and the amount of the fine. The act or omission must be one likely to cause damage to the employer or hindrance to his business. The fine itself must be a fair and reasonable one, and

(b) An employer shall not make any such deduction except in accordance with such a contract. No fine can be inflicted unless and until the workman to be fined has been furnished with the particulars for which he is penalised.

Shop assistants come under this Act as well as workmen. Where an employee has been fined illegally under this Act he can recover within six months of the fine.

Employees "Living In." As regards the general provisions of the Truck Act, shop assistants are not equally favoured. There has grown up in the large retail shops of many large towns of England a system known as "living in"—the unmarried assistants are supplied with meals and lodging in lieu of possibly more than half of their wages. The objections to this system are obvious. Men are herded together, the good and the bad without distinction. The State obviously cannot deal with morals, as such; but if the employer were handicapped by statute in his facilities in paying wages in kind, the system would receive a death-blow from which it could never hope to recover.

That is the purpose, without a doubt, of the movement of recent years, which, having resulted in a commission to see how far shop assistants can be brought under the conditions of the Truck Act, will indubitably result in legislation crippling a custom which has become an abuse.

Compensation. The whole question of compensation to workpeople has been settled by the Act of 1906, which, coming into force on July 1st, 1907, may be said to have revolutionised in one important particular the law upon the subject. For the first time domestic servants have been admitted to the advantages of compensation. It would not be possible to give in this place any synopsis of the rules and liabilities under the Act. Suffice to say that the prudent employer will now insure against any liability. We append therefore an ideal form of policy which is accepted by several of the better known insurance offices.

SPECIMEN POLICY

M.......... of .... (hereinafter called "the employer") having paid to the above company the sum of .... on account of premium for the indemnity hereinafter mentioned, it is hereby agreed as follows:

The company indemnifies the employer fully and completely against his or her entire liability (including costs), however protracted, under or by virtue of
The Workmen's Compensation Act, 1906,
The Employers' Liability Act, 1880,
Lord Campbell's Act, 1846,
The Common Law,
The Workmen's Compensation Acts, 1827 and 1900.
In respect of any injury fatal or non-fatal, which, at any time or times during the continuance of this policy, shall happen to any servant while in his or her employ, or while by law so deemed to be.

The company in cases of non-fatal accidents will, in lieu of the payment of half the weekly wages provided by the Workmen's Compensation Act, 1906, allow the employer the full wages paid during the period the employee is totally incapacitated from work up to one month from the date of the accident, and thereafter the benefits allowed by the Act, and will reimburse the employer any reasonable medical expenses he may incur in connection with such accident up to but not exceeding five pounds (£5) in amount.

The company shall at its own cost take upon itself the settlement of any claim, and the employer shall not, except at his own cost, make any payment, settlement, or arrangement. The company shall, at its own cost, take over and conduct and control the defence of any proceedings taken to enforce any claim, and defend the same in the name of the employer.

The employer by the acceptance of this policy agrees:

To give notice to the company at its head or branch office of any accident, within a reasonable period of the time when it comes to his knowledge, and of any claim, either verbal or in writing, made upon him.

To render the company at the cost of the company all reasonable assistance in connection with any accident, or any claim which may arise under this policy, and at the expiration of each year of insurance to furnish a statement showing the total number of persons employed during the year, and to pay to the company any additional premium which may be due in respect of persons employed in addition to those on which premium shall have been previously paid (to which additional servants it is hereby agreed that this policy shall in the meantime apply).

In consideration of an extra premium of .... it is agreed that this policy shall extend to protect the employer against all liabilities under the Workmen's Compensation Act, 1906, to persons not in the employer's permanent service, and temporarily or occasionally employed by him in his capacity of a private householder or of an occupier of office or business premises, or for purposes incidental thereto.

This policy shall be in force for twelve calendar months from the date hereof.

Landlord and Tenant. The folly of the average layman is exemplified in no department of law so much as in the carelessness with which the leasing of houses and rooms is concerned. Tenancies are entered into without agreements stamped and properly sealed, with the result that the tenants entail upon themselves much hardship, and what seems to them to be illegality. At the outset, then, we would offer this golden rule:

Never enter into any tenancy which is for over a year without having a properly stamped and signed agreement. The value of the stamp required will only be a few shillings, and the advantage of security will be incalculable. The tenant should also be careful to note that the lease contains clear and express provision as to the amount of rent, the mode of payment, and the notice required for the termination of the tenancy.

As a matter of practice, most tenants, certainly in humble circumstances and in agricultural districts, are content to take a tenancy without any agreement in writing. In such cases, if they pay weekly, they are weekly tenants; if monthly, they are monthly tenants, and can terminate their tenancy by a month's notice. Causes of perplexity not

infrequently occur where the tenancy has begun on a year's agreement which has come to an end. The tenant continues in occupation. His tenancy is then governed (in point of time) by the mode of payment. If his rent is paid quarterly, he is a quarterly tenant, and must pay and give notice on the day he desires to terminate his tenancy.

Mode of Notice. Notice, whether given by the landlord or tenant, may be verbal, but the onus is upon the person giving it to show that, if verbal, it was properly given. Thus it would not be considered a good notice if the tenant called at the landlord's house and rang the bell, and on being informed that the landlord was not at home, left the verbal notice with the servant to hand on to the landlord. Nor is it a good notice when the date of leaving is placed at a day and time which is not legally in accordance with the requirements of the tenancy. Such a notice is altogether bad, and may be disregarded. The tenancy always expires at midnight on the date fixed for termination of the tenancy, and the tenant cannot be called upon to quit the premises before.

The landlord's remedies against a tenant who fails to pay his rent are dealt with briefly in another place, but here it may be said that where cases arise of tenants "flitting," leaving the house or rooms barred up and empty, the landlord is entitled to break in and obtain possession. If the tenant should happen to have left anything of value behind, the landlord may sell the same to cover the arrears of rent, and such rent as would be due in lieu of proper notice. But he is not entitled to double rent from the departed tenant and a new one, should he have succeeded in obtaining a new one.

Distress. The landlord's remedy where the tenant fails to pay his rent is by "distress," which can only be levied by a certificated bailiff, and must be between the hours of sunrise and sunset. Even then, the landlord must see to it that there is no forcing or breaking into the house, for the rule of the law is that "an Englishman's house is his castle." The bedding of the tenant and his family, and wearing apparel in actual use, and tools and implements of his trade to the value of £5, must not be distrained upon. Goods belonging to a lodger or visitor in the house should not be seized, but it is incumbent upon them to serve a declaration of ownership upon the landlord, accompanied by an inventory specifying the property in question. It may also be added that:

Kitchen ranges, stoves, coppers, grates, and other fixtures of the like nature put up by the tenant for the more convenient or profitable use of the demised premises, and which he is entitled to sever and remove during the term, are not distrainable for rent.

The other rules for distress, inasmuch as the process is compulsorily in the hands of experienced people, need not be given here. It will be enough to add for the benefit of unfortunate tenants that the penalties for illegal distress are very heavy.

Another branch of house letting of importance to tenants concerns the question of repairs.

Repairs. Probably it would always be safer to specify more fully than is habitual at present the repairs for which the landlord is responsible, and those which should be upon the tenant. At present, the favourite phrase is "*tenantable repair*," and the necessity of keeping the house in this condition is upon the landlord. But the meaning of that phrase is rather an elastic one. It is not, indeed, possible to define it more than generally. In as few words as possible, it may be said that the landlord must keep the house in a habitable condition. If the roof falls in, or one of the ceilings, if the cellar becomes full of water, he must see to rectifying these defects. But he will not be responsible for broken sash cords, or door handles that tumble off, or if the chimney smokes.

Failing, however, any express agreement, the landlord has no such liability at all. There is no implied warranty on his part that he will keep the premises habitable, or rebuild them in case the roof falls in or they are burnt down. So a tenant who is burnt out will find himself under the unpleasing necessity of still having to pay rent. And more than that, the landlord can get the insurance money for the destroyed premises and yet refuse to rebuild them. Surely this may be said to be a branch of our law conspicuous by its oddity.

Fair Wear and Tear. The responsibility upon the tenant, in the absence of any express agreement, is to leave the premises at the expiration of his tenancy in a reasonably clean condition, fair wear and tear being allowed. But if he has pulled down a wall during his tenancy he must rebuild it, of course, unless he has obtained the landlord's permission for the structural alteration. This branch of our subject includes the question of fixtures, the legal aspect of which has given rise to much perplexity in the past.

The broad rule is that the tenant, at the expiration of his lease, may *remove trade and ornamental fixtures, but he must take care that in so doing he does no damage to the fabric.* Thus, a chandelier put up by the tenant may be taken down only if the ceiling is left in proper condition. Trees and shrubs planted by the tenant could be removed if by so doing no harm was done to the garden—a rather prohibitive condition. The tenant in such cases would be in a better condition if he happened to be a nurseryman, and could describe these articles as trade fixtures.

A shop window or counter or show-cases can be removed at the end of the tenancy, but the premises must be restored to their former condition. It will be seen then that the subject is one on which no definite rules can be enunciated. The safest course in all cases is to make these alterations the subject of express agreement with the landlord. The tenant who, for instance, is at the expense to fit up the premises as a shop, and then discover that it will cost more to remove his fixtures, must bear in mind that he will not be entitled to any compensation from the landlord for the things left behind—unless, of course, the whole matter had been the subject originally of express agreement.

PERSONAL LAW

"He who is his own lawyer has a fool for his client" is a saying which has in it much truth and much fallacy. At any rate it applies to lawyers as well as laymen, for the family which had good cause to rue home-made law was that of a former Lord Chancellor who drew up his own will with remunerative consequences to the class from which he sprang. But the drafting of legal documents is another story. And here it may be said at the outset that the drafting of legal documents, wills, contracts, bills of sale, deeds of gift, should never be undertaken by amateurs, however vital the needs of economy. If a man has twenty pounds to leave behind him, it will be far cheaper in the long run to have that trumpery amount conveyed by a proper will executed by a qualified solicitor. Home-made drafts are short cuts to litigation; the man who uses them may write himself down penny wise and pound foolish.

But in daily life legal points arise, too trivial to take to a solicitor, or perhaps too sudden to leave time for consultation. Often in a man's business or employment, or in his relations with his landlord or his tenants, or with the doctor who attends his children, or the schoolmaster who teaches them, he takes a false step sufficient to put him out of court for ever so far as that particular case is concerned. Husband and wife, through ignorance of a minimum of law, may entail consequences upon themselves of a most uncomfortable kind, to say nothing of the legacy of woe daily left to children by married persons who are ignorant or careless, or both.

Husband and Wife. The only bars to marriage under our law are disabilities through five causes:

(*a*) Mental Incapacity. A marriage with a lunatic "so found by inquisition" is void, or with a person who, though not the subject of an inquisition, can be proved to have been insane at the time of the marriage. "Insanity" must, of course, be taken to mean real, definite insanity, not mere oddness or eccentricity. It may be added that to go through a form of marriage with a declared lunatic (so found by inquisition) is punishable as a very serious contempt of court.

(*b*) Age. Marriages contracted under fourteen by the male and under twelve by the female are voidable—that is, they can be annulled at the will of either of the parties on reaching the marriage age.

(*c*) Relationship. The prohibited degrees of relationship are to be found in the Prayer Book. These include illegitimate relations and relations by the half-blood. Thus, a man may not marry his deceased wife's step-sister, though there may have been no blood tie between the women at all; also a man may not marry his deceased wife's illegitimate daughter.

(*d*) Prior Marriage. The existence of a prior marriage renders a new marriage absolutely null and void.

(*e*) Physical Incapacity is a ground for voiding a marriage. The distinction between *void* and *voidable* in the above paragraphs must be clearly understood. *Void* means null from the very beginning—never anything else: while *voidable* signifies that the marriage is a good one until either of the parties chooses to void it. But in the latter case, if it could be proved that a party chose to take advantage of its voidable character through capriciousness—*i.e.*, long after he or she knew that it was possible, the court might very well refuse to allow it to be voided.

Formalities of Marriage. Marriage can be solemnised according to the rites of the Church of England, or civilly. Thirdly, there are Nonconformist marriages.

Church of England Marriages are either by Banns, Licence, "Special" Licence, or Registrar's Certificate.

(1) Banns. The Marriage Act, 1823, directs that:

All banns of matrimony shall be published in an audible manner in the parish church or in some public chapel, in which chapel banns of matrimony may now or may hereafter be lawfully published, of or belonging to such parish or chapelry wherein the parties may be married shall dwell, according to the form of words prescribed by the rubric prefixed to the office of matrimony in the Book of Common Prayer, upon three Sundays preceding the solemnisation of the marriage, during the time of Morning Service or of Evening Service [*if there shall be no Morning Service in such church or chapel, upon the Sunday upon which such banns shall be so published*], *immediately after the Morning Lesson, or whensoever it shall happen that the parties to be married shall dwell in diverse parishes or chapelries, the banns shall in like manner be published in the church or in any such chapel as aforesaid belonging to such parish or chapelry wherein such parties shall dwell.*

If the names of the parties are misstated in the publication of the banns, and this misstatement is the result of false information given *with the knowledge of both parties*, the marriage is void. One wrong name might not render the marriage void, though this is possible. If the misdescription can be proved to have been due to no fraudulent intention, or if only known to one of the parties, the marriage is good. A misdescription of status, as where a widow describes herself as a spinster, does not matter, and has no effect upon the validity of the marriage.

Seven days' notice of the publication of the banns must be given to the clergyman of the parish: consequently it must follow that *twenty-two days'* residence is compulsory in the parish on the part of the party who has to obtain residence in the parish for the publication of banns. This, of course, refers to a person who has no parish of his or her own. Then, "a traveller is a parishioner of every parish he comes to": accordingly the man (without a parish of his own) who desires to marry a woman, say in Folkestone, must himself become a resident in that parish (or any parish where he chooses that his banns shall be published) by remaining there seven days to cover the notice to the clergyman, and fifteen days to cover the three Sundays when the banns are put up. If the marriage does not take place within three months after the complete publication, then there must be republication for three Sundays.

The marriage must be solemnised in one of the parish churches in which the banns were published.

(2) Licence. Where it is desired to dispense with banns, Church of England marriages can be by licence, to be obtained from the episcopal head of the diocese in which the marriage is to take place. No licence can be granted unless there has been a residence *for fifteen days by one of the parties* in the parish where the marriage is to be celebrated. Then before the licence is granted one of the parties must swear before the bishop's officer that there is no lawful impediment of kindred and that there has been fifteen days' residence, and if either party is a minor, and not previously married, then that the consent of the parent or guardian has been obtained. A false oath in regard to any of these particulars is a misdemeanour and punishable as such.

The licence must be produced for the clergyman at the marriage, and will be retained by him. The cost of such a licence varies in different dioceses from £2 to £4.

(3) Special Licence. Special licences, which cost £30, can authorise marriage without residence, at any hour of the day or night, and in any place whether consecrated or not. The special licence is granted only by the Archbishop of Canterbury, for any part of England, and the application for it must be accompanied with an affidavit giving particulars as to names, etc., and made to the office of the Vicar-General.

(4) Registrar's Certificate. Marriages may also be solemnised in church on a registrar's

certificate. This certificate is also used in Nonconformist marriages and will be treated under that head.

Nonconformist Marriages. By the present laws of the land marriages between persons belonging to denominations other than the Church of England are validly solemnised in the places of worship of the denominations to which the parties belong. A notice to the registrar is required, after which a certificate or licence is granted and the marriage can proceed.

A registrar's certificate or licence is valid for marriages in Church of England or Nonconformist places of worship, or for civil marriages.

A form must be procured by one of the parties from the registrar's office, and filled in with the full names, status, etc., of the contracting parties. Anyone who wilfully signs a false statement knowing it to be false is guilty of perjury and can, on conviction, be sent to penal servitude. At the time of giving notice the party must also make a solemn declaration of seven days' residence (fifteen, if the marriage is to be by licence) in the district of the superintendent registrar.

If either of the parties is a minor, then this solemn declaration must contain a statement that the marriage is taking place with the consent of those entitled to withhold it.

A false statement wilfully made is perjury, and can be punished, on conviction, by penal servitude. But such false statement does not render the marriage void.

The notice of such a marriage must be conspicuously exhibited in the office of the superintendent registrar for twenty-four hours prior to the solemnisation of the marriage, to give an opportunity for any authorised objection.

Following upon the notice, the parties can take their choice of a licence or a certificate. The former is the more expensive and the more expeditious. In the case of the licence also the need of a public exhibition of the notice is dispensed with. The fees in either case are not very high, and the exact formalities as to prior residence in the district will always be given at the office of the superintendent registrar.

The certificates or licences above referred to are valid for the solemnisation of marriage in a place of worship or in a registrar's office.

Marriages must in that case be solemnised in the usual form before the superintendent registrar in the presence of two witnesses.

Marriages Abroad. The question of marriages abroad opens too wide a subject to be dealt with in an article written for laymen. One golden rule taken to heart by British men and women in foreign countries will save much future unhappiness. Never enter into a marriage contract with a non-British subject without first finding out from the British Consul in that particular place how to set about making the ceremony a valid one, both by English law *and the law of the land in which the marriage is celebrated.*

The rule of our law is that every child born of the wife after lawful wedlock is presumed begotten of lawful intercourse, and therefore legitimate.

But if it can be conclusively proved that the husband has had no access to his wife the child can be bastardised.

The old days, when a husband could chastise his wife or take her to Smithfield, there to sell her to the highest bidder, have passed away for ever. In the eyes of the law, as it stands to-day, a husband is entitled to be master in his own home, but is no longer allowed to be tyrant. A married woman has many legal opportunities of getting away from a husband who is capriciously domineering, orders for the sake of ordering, or attempts to rule the household to beyond the limit of what is really reasonable.

Married Woman's Property Act. It is obviously impossible in this place to give the thousand-and-one details of the law governing the relations between husband and wife. Inasmuch as the bedrock of those relations is usually the question of property, it will be enough here to refer fully to what may be called the Magna Charta of married life—the Married Woman's Property Act of 1882. The main clause of the Act is the first. For that reason it is given in full in this place.

1.—1. *A married woman shall, in accordance with the provisions of this Act, be capable of acquiring, holding, and disposing by will or otherwise of any real or personal property as her separate property, in the same manner as if she were a femme sole, without the intervention of any trustee.*

2. *A married woman shall be capable of entering into and rendering herself liable in respect of and to the extent of her separate property on any contract, and of suing and being sued, either in contract or in tort, or otherwise, in all respects as if she were a femme sole, and her husband need not be joined with her as plaintiff or defendant, or be made a party to any action or other legal proceeding brought by or taken against her; and any damages or costs recovered by her in any such action or proceeding shall be her separate property; and any damages or costs recovered against her in any such action or proceeding shall be payable out of her separate property, and not otherwise.*

3. *Every contract entered into by a married woman shall be deemed to be a contract entered into by her with respect to and to bind her separate property, unless the contrary be shown.*

4. *Every contract entered into by a married woman with respect to and to bind her separate property shall bind not only the separate property which she is possessed of or entitled to at the date of the contract, but also all separate property which she may thereafter acquire.*

5. *Every married woman carrying on a trade separately from her husband shall, in respect of her separate property, be subject to the bankruptcy laws in the same way as if she were a femme sole.*

The remainder of the Act is equally important. It provides remedies of married women for protection and security of separate property. Another section refers to the wife's ante-nuptial debts, for which the husband is responsible only to the extent of any property of hers of which he has the enjoyment. But whereas that Act has the effect of putting married women on an equality with all other adults in respect to the owning of property, the law has gone a step further and endowed them with a privilege denied to everyone else. This is the *Restraint of Anticipation*, which is permitted to be added to any gift of land or income made to a married woman. During her husband's lifetime she may enjoy this income or the land as her separate estate, but she may not alienate it. Directly he dies she may dispose of it as she pleases—capitalise it, if it is income; sell it, if it is land; give it away or exchange it.

These broad lines, then, are sufficient to show the main features of the law governing marital relations where property is concerned. One important subsidiary question remains: *How far is a husband*

responsible for his wife's debts? It can only be said that the law is by no means settled. For her debts contracted prior to the marriage he is responsible only to the extent of her estate which he may enjoy.

But the debts contracted during marriage are another matter. He may safeguard himself, it is true, by advertising in the newspapers that he will not be responsible, but that is a counsel of despair not likely to be thought of until the mischief is done. At the same time there is the point of view of the creditor to be considered, the tradesman who sells the goods and has a right to expect payment.

Probably in no recent instance has the need of a code ever been more emphatically instanced. Paquin *v.* Beauclerk (otherwise Holden), the last recorded case upon the subject (1906), equally divided the House of Lords, with the result that the Lord Chancellor (Loreburn) and Lord Macnaghten took one view, while their two legal brethren, Lords Robertson and Atkinson, took the other.

The result is to make it possible only to state the rough rule with considerable doubt. Within the next few years, months even, what lawyers now regard as settled upon the subject may be altered, and a definite code be established as to how far married women may contract debts on their own and their husband's credit.

The Tradesman's Liability. As the law stands, then, a tradesman who supplies a married woman with necessaries befitting her apparent station in life, or with goods for use in the household, must look for payment to the husband. Groceries supplied to a villa residence in Sydenham must be paid for by the husband. It matters not that he has given his wife fifteen pounds a week for household expenses, and she has spent the money instead on cards and racing and finery; the unpaid household bills are accumulating against his credit, and he must pay them or no one else can be made to. But the tradesman is called upon to exercise a little discretion. The wine merchant who, on the wife's order, sends in five dozen of his best brand of champagne to the house in Park Lane where he knows the husband to be living is in a worse position as regards the wife's liability than if he takes an identical order for a lady whom he has every reason to believe is a widow, though living in an equally expensive neighbourhood. Again, the draper who sells a bricklayer's wife an expensive piece of silk may find it difficult to prove the liability of the bricklayer to defray the bill. But these are refinements which lead only to confusion. Summed up in a simple sentence, the present rule is *Caveat vendor*, the creditor supplies a married woman at his own risk.

The End of Marriage. The methods of ending marriage other than death are numerous. If the wife is guilty of misconduct the husband can obtain a divorce. If she deserts him, he can no longer compel her to return to him, except through the process of the court, and to the extent that that will help him. Certainly he may not employ physical violence, or constraint in any shape or form. Just as the Married Woman's Property Act is the charter of her liberties as regards property, so the *Jackson Case* may be called the seal of her freedom. The decision in that case laid it down once and for all, so far as our law is concerned, that the wife could not be constrained to live with her husband against her will. Both parties are now in the same position.

The party desirous of cohabitation, whether husband or wife, may sue for restitution of conjugal rights. The other side failing to comply within a specified period, the only course then left is to petition for a judicial separation. This does not allow either side to marry again, but neither side can afford to disregard it without the consent of the other. It acts as an absolute bar to any meeting. The party against whom it is granted, if the husband, or the wife with money, will also find him or herself burdened with the payment of maintenance to the other side, while the custody of the children will also be in the hands of the petitioner, though the respondent will not be denied reasonable access to them.

The Wife's Claims to Divorce. The same remedy is in the hands of the wife whose husband has been guilty of misconduct; for a wife cannot obtain a divorce unless she can prove that her husband, in addition to misconduct, has also been guilty of legal cruelty. Mere rudeness or an occasional outburst of temper on the husband's part is not enough. The wife must prove that her husband has been systematically cruel, and that his behaviour has had a bad effect upon her health. She may also obtain a divorce if the misconduct is coupled with desertion without any reasonable cause for a minimum period of two years. There are certain crimes on the part of the husband which entitle the wife to petition for divorce. It remains to state that the husband against whom a decree is made will have to provide for the maintenance of his divorced wife and children, and though the custody of the children will be with the wife, he will not be denied reasonable access to them. It is different with the wrongdoing wife. The court will not grant her access to her children under 16 years of age. With children over 16 years the court has no concern, and refuses to make any order. It must be noted that where a divorce is granted, a *decree nisi* is granted in the first instance, and the parties are not free to marry again until this decree has been made *absolute*. No decree will be granted where it can be proved that the petitioner subsequently condoned the misconduct, as knowingly resuming cohabitation with the guilty party. Nor will a decree be granted to a petitioner who has been proved to have been privy to the act of misconduct, nor to the party whose own conduct has palpably and glaringly conduced to the misconduct. Disappearance of a party to the marriage is not in itself a dissolution of the marriage. The other side must get leave from the matrimonial court to presume the death of the disappeared: and whether this will be granted will depend on the length of the disappearance and the likelihood of death. To marry without such permission is bigamy.

One word of general interest to laymen must be mentioned. Poor people are now enabled by law to petition for a divorce at a very small cost. The Probate and Divorce Division of the High Court, Law Courts, Strand, London, should be applied to in the first instance, and the mode of procedure will be pointed out.

Parent and Child. The modern parent is no longer an absolute tyrant. He is a constitutional monarch. He has a right to exact obedience from his child who is still a minor (under 21 years); he can withhold his consent to his child's marriage, and no marriage can be solemnised without that consent. But it is a very negative sort of privilege. Thus the solemnising clergyman, or the registrar who issues the licence or the certificate, may assume that the consent is given, unless he is informed that the contrary is the case. Consequently the onus is upon the non-consenting parent, and when it is remembered what opportunities for secret marriages our very elaborate civilisation offers young persons, it will be seen that in modern life the parent has very little say in the matter. The fact that he opposes

the marriage when he learns about it does not render the union null and void. Of course, a parent can use reasonable constraint on the person of the child—a young person predisposed to a specific act of matrimony against the wishes of the parent may be even locked up in a room, but such " durance vile " must not go beyond what is reasonable discipline. It must not savour of cruelty at all, nor have any injurious effect upon the health of the child, for here the community steps in, and it becomes a matter for the police court.

The parent, again, is the chief arbiter as to the religion of the child, or he may decide to teach the child no religion at all. Again, he may decide what secular instruction the child is to receive and where, but he must arrange that the child *is* taught, or the State will step in and do it for him. The parent, however poor, will be responsible for the maintenance of the child, and if the latter is starved or neglected wilfully (save, of course, through the misfortune of the parent), the latter is criminally responsible. Conversely, adult children are civilly responsible for the maintenance (or a contribution thereto) of destitute parents. Parental control does not continue in the case of children over 21 years.

Wills. No such view of law as the present one would be quite complete without a few words on the subject of wills. Persons who have property to leave should be warned to avoid home-made wills. In no other branch of law is the rule so often exemplified that " the man who acts as his own lawyer has a fool for a client." But if testators will insist upon making their own wills, let them make a point of simplicity, unambiguity, and clearness. The use of technical words is to be deprecated. If they employ them, it will be assumed that they know the meaning of the words they use. Neither stamps nor seal are now required to the validity of a will. It may be drawn up in any form the testator pleases, but it must be signed at the end by the testator and two witnesses in each other's presence. Creditors and executors are competent witnesses, but not beneficiaries. It may be added, however, in this respect, that the will is bad only so far as it concerns the beneficiary witness. But such a beneficiary witness may be given a legacy by a codicil which is duly witnessed by other witnesses.

Intestacy. Intestacy is the term applied to a person who dies without leaving a will. The rules for the division of such property are very clearly defined. But no family of an intestate should attempt to divide the estate except with the help of a solicitor.

The office of executor is not by any means an easy one. It is his duty to wind up the estate, and he must bear in mind that his responsibility for proper administration is a very heavy one. It is open to him to renounce the position at the outset, but if he accepts it is incumbent upon him to carry the will through to probate. If this is not done within six months he lays himself open to a very heavy fine. The Chancery Court however, will give relief in special cases. A public trustee has now been appointed by Act of Parliament, and come into existence from January 1st, 1908. He is a government official who, in return for a small fee, acts as trustee, and (if required) executor, in small and large estates. The security thus given against the fraudulent conversion of trust funds is obvious.

A SHORT DICTIONARY OF TERMS USED IN LAW

AGENT—A person authorised to contract legal obligations and acquire legal rights, and generally to enter into relations involving rights and duties on behalf of another, from whom his authority is derived.

Agreement—A mutual contract or consideration between the parties.

Aliens—Subjects of a State other than that in which they happen to be residing temporarily or permanently.

Ancient Lights—Uninterrupted enjoyment of light for twenty years.

Antenuptial Settlements—Settlement of property, etc., upon an individual prior to his (or her) marriage.

Appearance—Attendance, either in person or by proxy, at a court of law in reply to a demand for reparation.

Arson—Deliberately setting fire to buildings or such property as mines, crops, etc.

Assignment—The conveyance by the holder of a lease or part of a lease to a third person or set of persons.

Assurance—Guarantees to cover risks and compensate for losses, given by one party to another for payment.

Attestation—The act of witnessing: the signatures of the witnesses when complete.

Attorney, Power of—The delegation capacity to enter into binding arrangements on behalf of the person so delegating.

BAIL—Security taken by the court that a person charged will attend at a future date to answer to the charge.

Bailee—The holder of goods to obey the direction with which the delivery to him is made.

Bailiffs—Officers of the court employed to prosecute directions and orders of the court as to ejectment and distress for rent.

Bankruptcy—Insufficient assets to cover all just claims, and such insufficiency publicly declared by some act.

Barratry—Wilful damage to ship or cargo done by master or any member of the crew, without the privity of the owner.

Barring of Action—Limiting of right to bring an action after a certain interval of time.

Battery—A hostile touch or the hostilely throwing of anything at another person, or spitting at him. Practically a convertible term in law for Assault.

Bequest—Property left by will.

Bigamy—The offence of going through the ceremony of marriage when the first husband or wife is still alive, and the former marriage has not been dissolved.

Bills of Exchange—A bill of exchange is an unconditional order in writing, addressed by one person to another, signed by the person giving it, requiring the person to whom it is addressed to pay on demand, or at a fixed and determined future time, a certain sum in money, to, or to the order of, a specified person, or to bearer.

Bills of Sale—Documents operating as the transfer of property from vendor to purchaser, or as the evidence of such transfer.

Breach of Condition, Contract, etc.—Breaking the agreement to perform a certain act, etc.

Burgess—Enrolled and fully qualified member of a borough.

CESTUI QUE TRUST—The person for whose benefit the trust has been instituted.

Champerty—Bargain between third party and a party to a suit, to divide the object of the suit (land), if successful; supplying in return money to prosecute the suit.

Chattels—Personal property.

Cheque—An authorisation to the bank (or holder of any deposits) to pay a sum of money belonging to the drawer of the cheque to the payee.

Claim, Statement of—The legal document used in proceedings to set forth the demands of the suitor who is the plaintiff in the case.

Collusion—A private understanding between parties, made to influence or negative the course of justice. Used principally in cases in the Divorce Court, where husband and wife have a private understanding with a view to obtaining a dissolution of their marriage.

Compounding—Agreeing to suppress a crime, so that the wrongdoer may not be brought to justice.

Conjugal Rights—The rights of husband and wife to the society and support of the other. The compulsory common life.

Consideration—The reason demanded in law for the passing of any property from one person to another.

Contracts—Agreements between two or more parties to perform some act or pass property, etc., etc.

Contributory Negligence—Negligence in law on the part of any victim of an accident, disqualifying him from obtaining compensation from the employer or person responsible primarily for the accident.

Copyhold Estates—Tenancies held from the lord of the manor and entered in the Court Rolls of the Manor.

Copyright—The property in writings or paintings, etc., which prohibits their reproduction save at the will of the owner of the (copyright) property.

Corporations—Bodies of individuals or shifting aggregates or institutions treated as single individuals as respects their powers to sue or be sued, but differing from individuals in this that they are immortal.

Counterfeiting—Making base imitations of the coin of the realm.

Counterpart—The duplicate of a document—*e.g.*, the lease, deposited with the lessor.

Covenants—Clauses in a lease promising to do or abstain from doing certain acts and duties in connection with the tenancy.

Curtilage—The same common fence surrounding a house and outbuilding.

DAMAGE FEASANT—Any person whose property is injured by the cattle of another straying thereon, without any contributory fault of his own, is entitled to seize the cattle and retain them until he has been compensated for the damage done. This is known as "distress damage feasant."

Damnum Sine Injuriâ — Damage caused without a wrongful act.

Debt Judgment—Debt found owing by the decision of the court. Money owed as the result of a judgment of the court.

Dedication of Highways—Devoting a thoroughfare (through specified legal means) to the use of the public.

Defamation—Blackening the character of another person, either by words uttered or written.

Default—Failure to appear in satisfaction of legal proceedings.

Delivery—The legal passing of the property in goods.

Demise—The granting of a term of years' interest in property.

Devise—Testamentary grant of property.

Dissolution—Legal termination of a contract—usually employed with regard to the contract of *partnership* or *marriage*.

Distress—"The taking, without legal process, cattle or goods as a pledge to compel the satisfaction of a demand, the performance of a duty, or the redress of an injury." (Woodfall.)

Domicile—The place where a person has his permanent abode, and whither (when absent) he has an intention of returning.

Drawee of Bill—The person in whose favour a bill is drawn (drawee or payee).

EASEMENT—A right over another's land, under which some service or enjoyment is vested in a person who has no property in the land, and no right to draw any profit from it.

Ejectment—Forcible expulsion of defaulting tenants from house or land.

Embezzlement—Robbery by a clerk or servant of his employer's money, etc.

Employers' Liability—Responsibility of employers to compensate workpeople injured in their service, by any cause other than the workman's own fault, or the fault of a fellow-work man.

Entail—The line of succession to land indicated.

Estate Duty—The taxes required to be paid on succession.

Execution of Judgment—Enforcement of decree of any court.

Executors and Administrators—Officers appointed under a will to fulfil the terms of the will and administer (so far as required) the estate.

FACTORS—Agents employed and empowered to buy and sell.

Fee Simple — Practically absolute ownership of personal property.

Fee Tail—A limited estate, or property in an estate.

Felony—"An offence which occasions a total forfeiture of either lands or goods or both, at common law, and to which capital or other punishment may be superadded according to the degree of guilt." (Russell.)

Foreclosure of Mortgage—Taking complete and actual possession of property upon which money has been raised, in default of repayment of said sums.

Forgery—Personating another through the means of counterfeited writing.

Fraud—Wilful misrepresentation in entering upon an agreement.

Freehold—Estates held in fee simple, fee tail, or for life. [q. v.]

GRACE, DAYS OF — Extensions allowed by law before a just debt, etc., becomes due after the actual date of repayment has vested.

Guarantee—The acceptance of the obligation of a third party to complete some agreement.

HEARSAY EVIDENCE—Report of words used by a third party not present before the inquiry.

Hereditaments—Inheritances applied to land.

Heriot—Feudal "service" due to the lord of the manor on the death of the tenant.

Highways—A way open and common to all the King's subjects.

Hire-purchase—Payment for goods, the actual possession of which has passed already to the purchaser, by instalments.

IMMEMORIAL USAGE — Custom which has obtained so long as the memory of man can extend back.

Indorsement—Signature of payee (or drawee) acting as negotiation of the bill.

Infants—Legal description of those who cannot enter into contracts for reasons of age.

In Formâ Pauperis—Facilities for suing or defending in courts of law where the suitor is too poor to employ legal aid.

Inhabited House Duty—A tax upon occupied houses, the incidence of which falls upon the occupier or landlord according to the rent paid.

Inland Bill of Exchange—A bill both drawn and payable upon presentation within the British Isles.

International Copyright—Protection of literary property extending over its production in foreign countries.

Interpleader—Process to ascertain real ownership of goods seized under a distress for rent.

Intestacy—Disposal of the property of a deceased person who leaves no will.

JETTISON—Throwing cargo overboard to save the ship.

Joint Tenancy—Two or more persons holding land in common.

Judicial Separation—Legal status (short of the dissolution of the marriage tie), pronounced by the Divorce Court, entailing living apart, but not entitling the parties to re-marry.

LADING, BILL OF—Document containing description, etc., of cargo consigned to a ship.

Larceny—Feloniously taking another person's property against his consent, with a view to converting to use of the taker.

Lien—Hold on property vested in persons having some claim upon the actual owner.

MALICE—The conscious violation of the law to another's detriment.

Market Overt—"A fair or market held at stated intervals, in a particular place, by virtue of a charter or prescription. In the City of London every shop is, on every day except Sunday, a market overt for the sale of goods usually sold therein." (Chitty.)

Memorandum of Association—Document demanded by law and containing the terms governing the formation of a limited liability company.

Misdemeanour—Any crime less than a felony (q.v.).

Mortgage—Security given by a debtor to his creditor, either on land or personalty, to safeguard the repayment of the amount owed.

Mortmain—Transfer of property to any corporation as distinct from individuals or cluster of individuals.

NECESSARIES—Articles supplied to infants or married women which they are bound to pay for personally as essentials to their mode or condition of life.

Negligence—Acts of commission or omission other than those likely to be done by a reasonable man.

PAROL—Verbal as opposed to written.

Perjury—Swearing to what one knows is false.

Personalty—Property in cash and movables as opposed to realty (land).

Privileged Communications—Letters to solicitors from their clients; or from a person to any professional man who he is consulting, and concerning matters which it is the professional man's calling to deal with.

Procuration, Powers of—Delegating authority to bind another to agreements, etc.

Promissory Note—A promise in writing to pay certain sums, made without qualification or condition.

RATIFICATION—Confirmation of any agreement.

Receiving Order—Term used in bankruptcy for appropriating the assets of a bankrupt towards the payment of his creditors.

Representations Fraudulent—Statements of untrue character made with the object of inducing others to enter into some agreement which they would not make if they knew the facts.

Repudiation — Refusal to complete terms of a contract, on the ground that said contract had been obtained by the other party by misrepresentation, etc.

Reversion—Possession of realty or personalty vesting after the death of the actual possessor.

Rights of Way—Public capacity to cross private property at certain points [see *easement*].

SEISIN—To become possessed of realty.

Stoppage in Transition—The stopping of goods on their way to the perspective possessor; for debt, and so on.

Surety—Individual who accepts responsibility for the performance of some obligation on the part of another.

TORTS—Civil wrong for which one is liable civilly, but not criminally.

Treasure Trove—Valuables, to which no owner can be traced, found either in public or private land.

WRIT—Legal document used in process of civil and criminal actions, setting forth the cause of action and formally demanding the satisfaction claimed by the plaintiff.

LAW *concluded*

WOOD-TURNING

Woodworkers' Lathe and other Tools. Work Between Centres. Chuck Work. Measurement. Square Turning. Ornamental Objects

Continued from page 6756

By JOSEPH G. HORNER

The Lathe. The craft of wood-turning is very ancient. It was formerly done by a reciprocating mandrel, operated by a bow and cord; or by an overhead spring pole, operated by a treadle. The bow and cord still survive in the East. All modern wood-turning lathes are fitted with continuously running mandrels. Lathes for wood-work are much plainer than those for metal turning, seldom comprising more than a plain ungeared headstock, a simple poppet, and a hand tee-rest. For some engineers' pattern turning, a plain slide rest is fitted and a large face-plate, or a special face lathe. But with these exceptions, and that of the ornamental turner, wood-turners' lathes have no aids to supplement the work of the hands. The fact is, a skilful turner is more nearly independent of his lathe and tools than most craftsmen, and excellent work is done by such men on lathes that would excite the derision of the engineer or the wealthy amateur. Wood-turning is one of the crafts in which manipulation is the supreme factor, one in which the essential tools are few in number, and very simple in character.

A large, high-class lathe, much superior to those usually found in wood-turners' shops, is shown in **1**, made by T. White & Sons, of Paisley. It is all of iron, while wood figures largely in much lathe construction. It is of large size, 12-in. centre, designed for pattern turning, and general utility. The following are the principal parts: the *bed*, A, having at one end the *headstock*, B, with the four-stepped cones, C, turned inside and out for perfect balance, and driven from the cones, D, on the countershaft, fitted with fast and loose pulleys. E is an iron *face-plate*, to which work can be screwed directly, or through an intermediary plate of wood. F is the *fork*, or *prong* centre. G is the *loose poppet*, or back poppet, or movable poppet, or loose head, and its centre is the *back* centre. It is fitted for turning long tapers, as on columns, by utilising the cross-traverse movement provided. The tool rest commonly used is the *tee-rest*, H, with which nine-tenths of wood-work is done. But for long pieces, a *slide-rest*, J, is provided, comprising the tool holder on a cross slide, adjustable across the top of the saddle, which is fitted to the bed with vee'd edges, and an adjustable strip. The saddle is travelled up and down the bed by a rack, K, the pinion of which, L, is actuated through a pair of gears, N and O, by the lower lever handle, M, the upper handle being for the cross traverse. A nest of drawers, P, is formed underneath the bed to receive the tools, and a rack, Q, adjacent, receives face-plates. R is the *back board* for tools in use.

Wood-turning Tools. The principal operations are performed with two tools only, the *gouge* [**2**] and the *chisel* [**3**], each being used in three or four different sizes. Both are true cutting tools, both require practice and skill in their manipulation, but all conceivable shapes are outlined by deft handling of these two. True, there are many others which complete a turner's kit, but they are only used for occasional finishing, smoothing, and correcting. All the roughing out, and by far the greater portion of the finishing also, are done by these two very simple tools. We will consider them and their work in turn.

The Gouge. This [**2**] is like no other gouge. It has a considerable convexity of the cutting edge, the reason of which is to prevent, or to lessen risk of hitching or catching of the revolving work against one corner of the tool, which would happen if an ordinary firmer gouge were used for turning; or if the gouge were ground like **4**, instead of like **5**. It is this rapid revolution of the work, with the centrifugal action, tending to knock the gouge away, that the turner, consciously, or instinctively, born of habit, always has to bear in mind. The beginner, after sundry hitchings, and damage to the work, his hands, or the tool, or all in unison, soon learns to present the gouge warily. The thing to remember is not to allow the work to catch in the sides of the gouge, but to do the cutting at and near the point *a* only. Bearing this in mind, faces that are perpendicular to the axis of rotation can be roughed down safely, the back of the gouge being held next the face being cut. Concave and convex portions are also easily cut, the back of the gouge always lying next the face being turned.

When turning a parallel, or straight portion, the gouge can be held straight forward [**6**]; but, generally, more rapid reduction can be effected by turning with a diagonal cut, or sideways, changing the direction of cutting towards right and left alternately. Deeper cutting can be done by this device than by straight-forward presentation, though the latter is suitable for taking finishing cuts. To suit details of work of different dimensions, gouges are made in different sizes, from $\frac{1}{4}$ in. to $1\frac{1}{4}$ in., so that either fine details or heavy roughing down can be done by selecting suitable gouges. The *handles* of these gouges [**2** and **6**] will be noted as being characterised by much leverage. To this, in fact, they owe so much of their value. The workman is thus able to control their movements in opposition to the severe stresses caused by the revolution of the work. A firm grip is taken at the fulcrum—that is, the place where the gouge lies on the rest [**6**]. The gouge is gripped there between the forefinger and thumb of the left hand, while the end of the handle, gripped in the right hand, is kept in constant movement in arcs of circles to suit the nature of the cutting being done. In some cases the side of the gouge is presented, as in taking a finishing cut in a bore [**7**]; **8** is a gouge used on the slide rest.

The Chisel. This [**3**] is the only turning chisel with a doubly bevelled edge like that of the axe, though used in quite a different manner. It is presented and traversed against the revolving work, cutting shavings at and near the obtuse-angled end. The degree of pressure exercised is controlled by the hands of the workman. The tool is gripped on the rest [**10**] by the forefinger and thumb of the left hand, similarly to the gouge, while the right manipulates the handle. Like the gouge, the chisel will turn straight and convex

portions, though not concave ones, unless of large radius. The point to observe is that cutting must not be done far away from the point, *a* [9], and, say, over one-third of the width from the point, otherwise the tool is liable to be caught, and damage the work. It can be used indifferently in right and left directions [11]. The chisel, like the gouge, if used properly, leaves a very smooth surface. The acute-angled corner of the chisel fulfils the special function of cutting down perpendicular, or nearly perpendicular faces [12], and of severance. Being so keen a wedge, it will cut deeply and rapidly, leaving the smoothest possible face. It cannot be used for turning like the other angled corner, but would be caught by the work if presented thus.

Scraping Tools. Though the gouge and chisel are the sheet anchors of the turner, it is obvious that they cannot cover all details of work, and especially in pieces of large dimensions. Thus, a disc on the face plate cannot be turned and finished with the side chisel. For this a *firmer* chisel, acting as a scrape, must be used. A deep hole can be roughed with the gouge, and partly smoothed with the keen angle of the side chisel, but a true, smooth face must be finished with a *side tool*. A concave portion can be roughed with the gouge, and is often finished with it; but frequently it is finished with a *round nose*, especially in work of large diameter. These and some other tools act by scraping only. Hence, as scraping roughens up the grain, the object always sought is to do as much preliminary work as possible with the gouge, and take the merest film off with the scraping tools. Round nose and side tools are shown on page 4261, in group 22.

Hard and Soft Woods. The relative utilities of scraping differ in the practice of turning hard and soft woods. It is done much more extensively in the first named than in the second. The reason is that the grain of hard wood does not become roughened up nearly so much as that of soft timbers. This, of course, is not an argument in favour of scraping, when turning can be done by the gouge and chisel. But when work is of a highly ornamental character, and of large dimensions, as in much of that done on the face-plate, the risks of hitching are lessened by the use of scraping tools. The harder the wood, the more nearly the conditions approach to the turning of the softer metals. Thus, Spanish mahogany is harder than baywood, and lignum vitæ or box are more suitably scraped than beech or birch. Also, dry, well-seasoned woods can be more readily scraped than moist and spongy stuff. So that there is room for exercise of judgment. When details have to be turned to exact dimensions the scrapes are valuable aids, because very minute amounts can be removed by their assistance. The hardwood turners, therefore, have a large assortment of scrapes for turning concave and convex portions, for recessed work, right and left-handed, besides special forms of tools for internal shoulderings, etc., in some of which it would be quite impossible to use the turning gouge or chisel.

All turned work may be classified under two heads, that done *between centres* and *chuck work*.

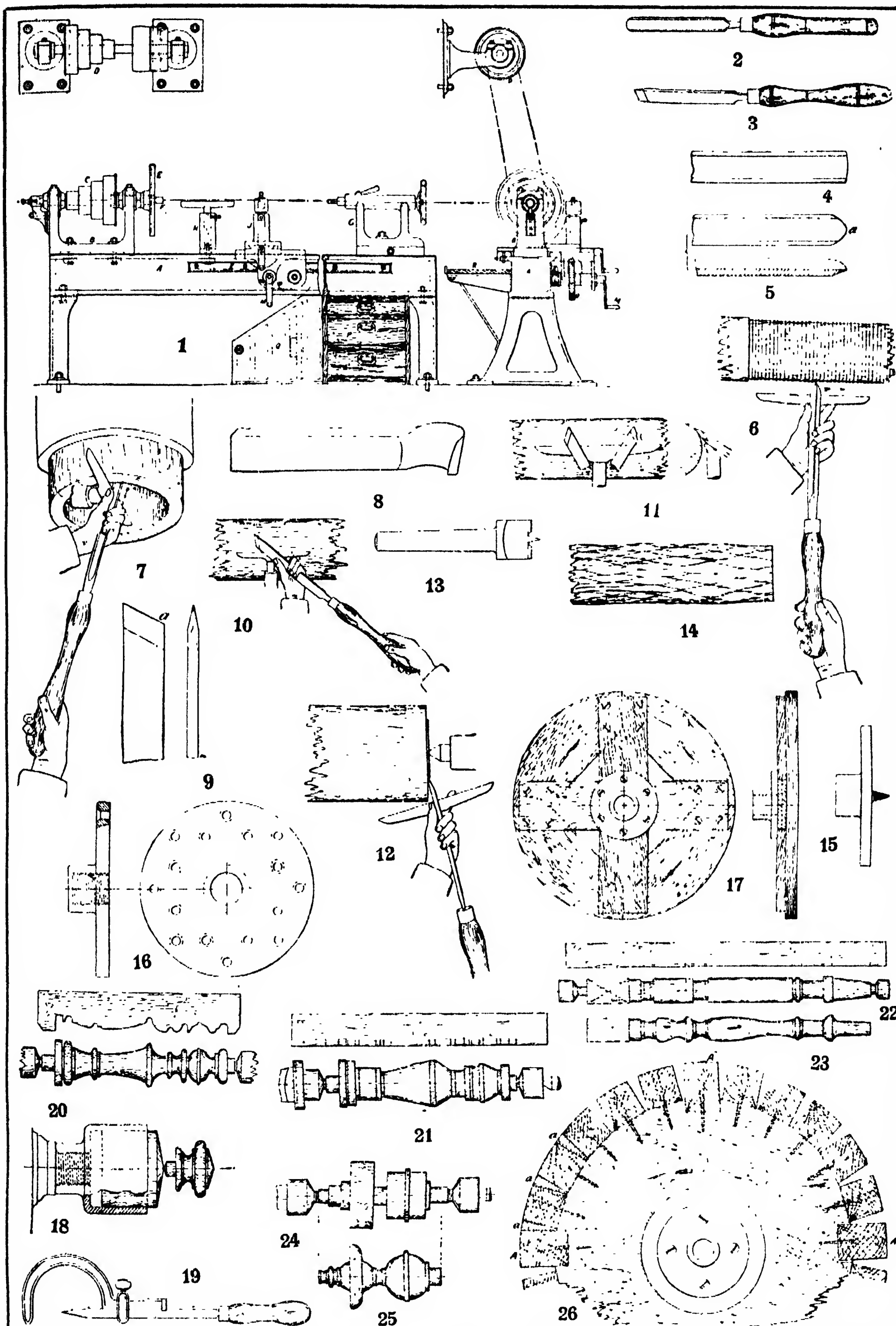
Work Between Centres. This signifies that the piece to be turned is supported and revolved between the fast headstock and the loose poppet. It includes all pieces the length of which exceeds the diameter by so much as to require support besides that afforded by the headstock. Generally, such pieces are held and rotated by the fork or prong centre. This is interchangeable with other chucks on the mandrel nose. It derives its name from its fork or prong-like character. The end of the wood, if soft, is driven against it, or, in hard wood, a saw kerf is often made to receive it. The back poppet centre is entered readily by screwing up the mandrel slightly. Occasionally other chucks are used to drive work between centres, but in most instances the fork is employed; 14 shows a piece of wood roughed out with the axe preliminary to turning.

Chuck Work. This signifies that pieces are held at the headstock end only, and without other support. Pieces the length of which does not greatly exceed the diameter, or which are of less thickness are turned thus.

Face-plates. These are the principal chucks. They differ from those for metal turning in their greater simplicity, comprising only two forms, in a range of dimensions. One is the *screw point chuck* [15]—that is, the work is held on it by a central, short, tapered screw, having a coarse thread. This is sufficient to hold a small piece of wood, say, not exceeding 4 in. or 5 in. in diameter. Thick blocks —say, above 3 in. or 4 in. diameter—are generally secured in addition with a couple or three wood screws put in from the back of the plate.

Large Face-plates. These [16] have countersunk holes for the attachment of work by wood screws inserted from the back of the plate. They are made in as large a range as the capacity of the lathe will admit. For very large face work, lathes are made either with a deep gap in front of the headstock, or the headstock is made to turn round through 90° or 180°, so that work can be taken as far down as the floor. In such cases a special rest is rigged up on a heavy *floor stand*, sufficiently massive to remain steady under the stress of turning. In many cases the trouble of reversing the headstock is avoided by carrying the mandrel out at the rear to hold the large face-plate, so that it is always ready for use. Pattern-makers, as well as wood-turners, use these face lathes for wheel work of all kinds.

Wooden Plates. The face-plates are made of iron, except in the very small sizes—say, under 4 in.—for which brass is commonly used. But a large proportion of turners' work, and much the largest in pattern turning, is done, not on the metal plates directly, but against an intermediary plate of wood screwed to the metal. The advantages are these: The wood plate can be faced up truly, while the metal plates often run slightly out of truth, due to wear on the thread. Turning can be done right up against the wood without inflicting damage on the tool edges. There is a slight elasticity in the wood, noticeable when turning, by comparison with turning done down close to the iron. But the principal advantage is that the wooden plates can be recessed to receive work for re-chucking centrally, often, too, without using screws, the friction of the work in its recess—or over a check standing out, in the case of chucking by a hole—being sufficient to retain it in place for light turning. In time, as a face-plate becomes turned down thus, a new one is substituted. Small plates are made of solid stuff; but those over 12 in. to 18 in. diameter are built up, the plainest with battens, the largest with a cross and diagonals [17]. Much work is chucked, not directly on the plate, but on blockings screwed to it. The reason is, that plates of several feet in diameter are rather expensive, and would soon wear out if frequently recessed. The face is, therefore, retained plane, and chuckings are done on



1. 12-in. centre wood-turning lathe 2. Turning gouge 3. Turning chisel 4. Turning gouge improperly ground 5. Turning gouge properly ground 6. Method of holding gouge 7. Finishing with gouge in hole 8. Slide rest roughing tool 9. Turning chisel 10. Method of holding chisel 11. Side chisel applied right and left hand 12. Side chisel cutting down an end 13. Fork or prong centre 14. Wood roughed for turning 15. Screw-point chuck 16. Large face-plate 17. Built-up wooden face-plate 18. Piece of work in cup chuck 19. Sizing tool 20. Finished article and its templet 21. Article as roughed out and strip marked out in lengths 22 and 23. Article roughed out and finished 24 and 25. Article roughed out and finished 26. Square turning

temporary blocks screwed to the face. This is done in large gear wheels, pulleys, and rings of various kinds.

There are some classes of turned work in which it is undesirable or inconvenient to insert screws, yet which must lie against a flat face-plate. Then *paper joints* are useful. These are adopted extensively in pattern turning, and it is surprising how great a mass paper will hold. Newspaper is suitable. It is glued on both sides, one side going next the plate, the other receiving the work. On large pieces, narrow strips of paper at intervals are sufficient; pieces of a few inches diameter may be carried with one piece of the same diameter. The joint is broken after turning by lifting the work with a chisel inserted in the joint, when the paper splits into two.

The Bell Chuck. The bell chuck is termed the *cup chuck* [18], and is used for some classes of work too small or too long for the face-plate, and also for pieces which have to be bored [7], or for objects that have to be turned and cut off in succession [18]. Boxes, egg-cups, vases, are examples of the first; drawer-knobs and cord-pulleys of the second. The wood is driven into the cup and holds by friction alone. The chuck is usually of brass.

There are many very delicate objects which will not bear any driving into the bell chuck, or into a wooden chuck driven into the bell, and recessed to receive work. For such objects the *spring chucks* are valuable. These are made generally in a hard wood, box being the best, sometimes also in brass. The body of the chuck, slightly tapered outside to receive a ring, is split by several saw kerfs cut radially nearly to the bottom of the chuck, and the metal ferrule is made to compress the body round the work by tightening it down the tapered body. Turners make these for their own use in several diameters.

Methods of Measuring. The diameters of turned work are mostly taken with common calipers. When large numbers of similar pieces have to be done the calipers are often fixed with a thumbscrew. A sizing tool [19] is also used with a guide at the back, for repetition parallel turning.

Dimensions in the longitudinal direction may be taken with a rule; but when quantities are done, a strip is generally used, having the various lengths marked across it, whence they are transferred to the work. In such cases the piece is roughed out approximately parallel to the largest diameters, and the lengths set off on the rotating piece. Then these are set in with the keen angle of the side chisel down to the various diameters, which are turned, and checked by the calipers. Every portion is first turned as a parallel section, after which the different moulding sections are shaped with the gouge and other tools. Compare 20 to 25.

Templets. These afford much aid to calipers in repetitive work. They are cut from a thin strip of wood and tried upon the work [20] from time to time as the final corrections are being made. A little chalk or red lead may be rubbed on the edge to indicate the localities where contact takes place.

Straight Shafts. When a long portion of turned work is to be perfectly straight, as in the shafts of columns and pillars, and in pattern pipe-turning, much time may be saved by first turning down at each end and in the centre to the correct diameter, and then planing a flat along from end to end, forming a tangent to the diameters. This, being chalked or red-leaded, becomes a guide to rapid reduction of all the intermediate portions, which can be turned almost to size without stopping the lathe. It is then easy to finish with a side chisel, and correct, finally, with a firmer chisel.

Steadies. When long, slender pieces are being turned between centres they wobble, and cannot be turned truly without support intermediate with the centres. These steadies are very plain by comparison with those used by metal turners. Sometimes a rigid rod only is wedged between the ways of the bed, to be kept in contact with the back of the work; but, generally, a block of wood or an iron bracket is bolted to the bed to carry either a vee-block or to receive semicircular blocks. A single vee-block will cover a moderate range of diameters, but semicircular blocks will fit only one side. The practice is to turn down a portion to the correct size, somewhere about the centre of the length; grip that with the steady blocks, and then proceed with the remainder of the turning. In very flimsy work the steady is shifted to two or three successive positions; or more than one steady is used. Lubrication is necessary, or the friction between the work and the steady will cause smoking, and char the wood. Soft soap is the best material to employ. If a lathe is fitted with a slide-rest, then a travelling steady which follows the work behind the tool can be used, as in metal-turners' lathes.

Square Turning. The principle of this is illustrated in 26. The articles to be turned are arranged round the periphery of two or more discs, which are driven between the centres, driving with a face-plate at one end attached to its disc, the other end being supported on the back centre. The pieces of wood are attached with screws, the lengths being in excess of the finished article, to allow of the portion with the holes to be cut off subsequently. It is not necessary to fill in the spaces between the pieces with a view to prevent breaking out of the grain by turning, but those who are not skilful in the use of the tools glue strips in, as shown at *a* in 26. The blocks, A, in the illustration are simply distance pieces, by which the end discs are retained rigidly. Of course, the larger the diameter of the ends the less will the slight curvature due to the radius be in amount, and generally such ends would have to be framed up with a cross and segments. After the faces have been turned corresponding with one position of the articles, they are turned round and re-screwed in successive fresh positions, until all four sides are finished.

Ornamental Objects. The work of the geometrical turner requires special high-class chucks, and a special lathe. But very beautiful, effective ornamentation can be produced by the plain wood-turner by the repetition of similar figures, such as those shown in 20 to 25, and allied forms, for there is no limit to the combinations of curves and straight lines which are possible. Vases, flower-holders, candlesticks, watchstands, work about overmantels, toilet-boxes, epergnes, and much beside, can be so made, or enriched with ornament. Much may be done by turning rings the cross sections of which are those of various geometrical figures, and cutting off arcs therefrom to form the tripod-legs for stands of various kinds, or for carved handles. These are turned on the face-plate, most figures requiring re-chucking; objects of square, circular, octagonal, or fluted sections can thus be produced by turning.

With regard to the finishing of woodwork, any of the usual preparations can be employed, according to the character of the wood and the work — brush varnishing, French polishing, lacquering, painting. Inferior woods may be stained previous to polishing.

WOOD-WORKING *concluded*

ADVERTISING

The General Avenues of Business Publicity. Mail Order Advertising. The Business of Advertising

Continued from page 6802

By WAREHAM SMITH

ADVERTISING is the art of creating a demand by publicity: it is to-day one of the greatest forces of commercial life, and it is no exaggeration to say that millions of pounds are spent annually in applying the power.

Advertising—the art of advertising—cannot be taught in the usual way. There are no text-books or acknowledged professors, and the attainment of a position in its ranks does not entail an expensive course of instruction or necessarily involve a long apprenticeship. The qualifications are a strong personality, a sound general education, and a keen perception. There is no business that offers greater advantages to the man who can see and grasp an opportunity.

We have said that advertising cannot be taught—nor can it. One may learn how to draw up an advertisement, what type to use, what space to buy, and how to buy it, and some useful hints are given in these pages on these points. You can learn a thousand and one things, useful and even necessary to know in the connection, but of themselves they are not advertising—they are not the *spirit* of advertising. It is the argument—the happy thought—the bright idea—the smart catch phrase—the power of perception—the insight into human nature, that sell the goods, and these things cannot be learned by rule of three.

Placing Advertising Business. It will be as well first of all to enter somewhat into the conditions of the advertising business. An advertiser wishing to inaugurate a campaign arranges details as to space, price, position, etc. (*a*) with the advertisement manager of the various publications direct; or (*b*) he employs an advertising agent to make the necessary arrangements; or (*c*) he places some contracts direct with the publisher, and some through an agency, as he may deem it expedient.

Generally speaking, the business is apportioned in the following way:

About nine-tenths of the total is done through advertising agents. The agents handle nearly all the business that is placed with daily newspapers. The monthly magazines accept a small amount of business from the advertiser direct. Of the advertising in the illustrated weeklies about 25 per cent. is arranged without the intervention of an agent. It will be seen from this that the advertising agencies play a very important part in the business, and their position in the field is rather a peculiar one for the reason that although they work ostensibly in the interests of the advertiser they receive their remuneration from the publisher. On all contracts placed by the agency the publisher pays a commission, varying generally from 10 per cent. to 15 per cent., according to the standing of his publication and its power to command business. Various other arrangements are often entered into between publisher and agency, such as an additional discount for cash or an extra commission if the business received exceeds a certain amount. There is no fixed rule, each publisher being a law unto himself in this respect, but 10 per cent. is the usual commission paid by first-class publications. The agency is responsible to the publisher for payment for contracts placed by it, and is regarded as a principal, all contracts being made as such, and not as an agent for the advertiser. The position of the agency is analogous to that of a man serving two masters, and although much controversy has arisen within recent times as to the efficiency of the system, still, as exemplified by first-class agencies, it appears to work satisfactorily.

The Advertising Agent. It is not perhaps of particular importance for present purposes to enquire into the inner working of an advertising agency, but it is at least relevant to the subject, and digression in this direction may not be uninteresting. The agency acts: (1) as space brokers—that is, buyers of space from the publisher on behalf of the advertiser; (2) as advertisement managers and advisers to the advertiser.

In either case the commission paid by the publisher is the same. Some agency businesses consist entirely of the former, some the latter—others combine the two according to the requirements of individual clients. Generally one of two methods is adopted by the advertiser in prosecuting his campaign: (1) The organisation of an advertisement department under the control of a man who combines a knowledge of advertising with a study of the exigencies of the advertiser's particular line of business, or (2) he places himself almost (in some cases *quite*) unreservedly in the hands of an agency. In the former case he makes such arrangements as will, in his opinion, ensure that his business will be properly and profitably conducted. His advertisement manager is generally a man with an extensive knowledge of the art of advertising. He has learnt from experience what to buy in the way of space, and the lowest rates at which it may be obtained. He designs copy, or has in his department experienced copy-writers, and, being on the spot, he has his fingers on the pulse of the business, and should be able to tell without loss of time when a publication or a particular advertisement fails to show a profit on the outlay. Almost invariably he employs an agency to act as space broker, to make the necessary arrangements with the publisher. By doing this he often saves time and money, the agency, acting for several advertisers, being frequently in a position to buy more cheaply; and, on the ground that service is not required in any other direction, the agency frequently comes to an arrangement with the advertiser concerning the commission received from the publisher.

Turning to the second method, the properly-equipped agency can and generally does render very important service to the advertiser, whether his outlay be large or small. It acts the part of an advertisement manager, and, in addition, brings to bear the experience gained by years of experimenting and observation made in the interests of numerous clients with diverse interests. The agency maps out the campaign, the publications to be used, advises as to buying space, and secures best positions possible. It writes the advertisement copy and

booklets; executes illustrations, and makes the process blocks; designs posters and sees that they are properly displayed; organises where necessary a follow-up system; originates selling schemes; checks accounts to make sure that the advertiser has received the space ordered and charged for, etc.

In addition to the business of space broker and advertisement manager to the advertiser, the agency sometimes undertakes the duties of advertisement manager to a publication—that is, it takes over the whole of the advertising space in the journal. This is known as "farming," and the financial arrangement is either a commission paid to the agency on the advertising revenue it earns for the publisher, or the payment of a fixed sum by the agency for a fixed amount of space.

These, then, are the conditions under which the business of advertising is conducted. A knowledge of advertising may be acquired in anyone, and applied to anyone. The defined tracks are—service with the advertiser, with the publisher, or, with the advertising agency. For service with an advertiser a knowledge of the following subjects is required: the writing of advertisements (technically copy-writing); conditions governing the buying and using of space in the press, and outdoor publicity; the buying of advertising material such as colour printing and show-cards; the weight of paper, etc.

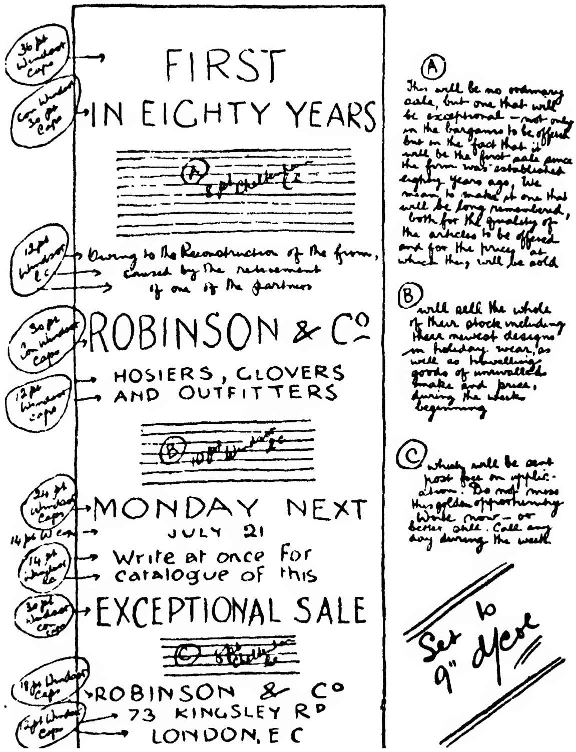
Copy-writing. The broad principles which must be followed, if advertising as a whole is to be successful, and a particular advertisement is to fulfil its purpose, may be stated as follows: an advertisement must (1) attract attention; (2) invite reading; (3) carry conviction.

Various devices are employed to arrest the eye of the reader. A distinctive border may be used with effect, but to rely on a border is to a certain extent a confession of weakness on the part of the text.

Pictorial blocks also find favour with many, but the picture which has no relation to the text is open to the same criticism as that applied to the distinctive border. If a block is used at all, the design should be an integral part of the advertisement as a whole. Such a block will serve a double purpose. It will arrest attention in the first instance, and will then fulfil the second requirement of a good advertisement by drawing the reader unconsciously to a perusal of the text. The same may be said of a pregnant and illuminative headline—a collection of words which gives, as it were, a slight mental shock to the reader, stimulates his curiosity, and makes him ask for more.

The Heading. To invite reading, as we have just seen, an advertisement must in the first place have a significant design or letter-press heading. After that, type-setting plays a very important part; excessive display should be avoided, and a generous allowance made for white space. Type of a smaller size set in an open manner will always present a more attractive appearance than type two or three sizes larger set so as to cover the whole space available. In order to sustain the interest of the reader the minor headings should, if possible, be made no less significant than the title itself. Up-to-date newspapers and magazines contain in their editorial columns excellent examples of the use of attractive cross-headings, which the advertiser who desires to give life to his advertisement will do well to study and imitate.

We now come to the most vital characteristic of a good advertisement. The announcement may be seen; it may be read; but if it fails to convince the reader of the merits of the commodity offered, and of the desirability of possessing it, all effort has been wasted. It is here that the art of the copy-writer comes into play. The qualities of good copy are so subtle that it would be hopeless to give any directions likely to help the aspirant. Suffice it to say that the best copy is clear without being wordy, terse without being obscure, eloquent without being extravagant.



1. EXAMPLE OF DUMMY ADVERTISEMENT

To write intelligently, an intimate knowledge of the article is required, its value from all points of view, what the buyer wants to know about it; and, equally important, what you want him to know. It should also be remembered that different subjects require different treatment; a motor-car cannot be advertised in the same way as a patent medicine. The public, too, vary in class and temperament, and a successful appeal to one class may prove a failure to another if the same point of view is taken.

The "Dummy" and its Uses. The copy-writer is furnished with particulars of the subject of the announcement and of the space allotted. His first duty is to rule off on a sheet of paper a diagram exactly the dimensions of the proposed

advertisement. This sheet, which should have a total area at least twice as large as that of the diagram, is known in printing offices as a "dummy." We shall assume that the copy-writer has drafted the text to his satisfaction, and that it now remains for him to adapt the text to the space before him. For the sake of simplicity we shall suppose that the advertisement will consist of letterpress only.

How to Make Headings Attractive. The main heading first claims attention. Sufficient space must be allowed to enable it to stand out clearly. White space should be left either on one side or on both. The heading which runs across

FIRST

IN EIGHTY YEARS.

This will be no ordinary sale, but one that will be exceptional—not only in the bargains to be offered, but in the fact that it will be the first sale since the firm was established eighty years ago. We mean to make it one that will be long remembered, both for the quality of the articles to be offered, and for the price at which they will be sold.

Owing to the Reconstruction of the firm, caused by the retirement of one of the partners,

ROBINSON & CO.,

HOSIERS, GLOVERS AND OUTFITTERS,

will sell the whole of their stock, including their newest designs in holiday wear, as well as travelling goods of unrivalled make and price, during the week, beginning

MONDAY NEXT,

JULY 21.

Write at once for Catalogue of this

EXCEPTIONAL SALE,

which will be sent post free on application. Do not miss this golden opportunity. Write now—or better still, call any day during the week.

ROBINSON & CO.,

73, KINGSLEY ROAD, LONDON, E.C.

2. ADVERTISEMENT SET UP FROM DUMMY

the full measure of space allotted is seldom effective. The secondary headings, in which doubtless other important features of the advertisement find expression, should next be considered. The probable distance between each should be calculated and care be taken that no two of them come too closely together. Should this appear likely to happen there is nothing for it but to alter the intervening text. The positions of headings or display lines being thus more or less settled, these headings may be sketched in on the "dummy," and the subsidiary matter, or, to give it a simpler term, the "story" may now be dealt with. If the story be a long one, any attempt to write it in the space left between the headings on the "dummy" will only give trouble to the unfortunate printer and result in typographical errors. A much better plan is to have it written separately, marked off in sections A, B, C, etc., the spaces in the "dummy" which each section is to fill being marked correspondingly.

The illustration [1] shows a "dummy" advertisement ready to hand to the printers, and 2 shows the same advertisement in type. At this stage the advertisement is known as a "proof." For instructions in correcting proofs, see page 4193.

Use and Abuse of Bold Type. The last point which falls to be considered is the choice of types. As a rule, this is a matter which may generally be left to the printers, if the copy is to be set in an office which is known to employ expert display compositors. It is a great mistake to insist on the use of bold type throughout. Bold type is all very well for headings, and even then it should be used with discrimination and in different degrees of boldness, otherwise one heading will kill the other. In the body, bold type should never be used except for one or two lines at a time which require special emphasis. The eye soon tires of following more than a dozen lines emphasised in this manner. For different styles of type, see article beginning on page 5026.

Some Devices of Display. The advertisement shown in "dummy" and in type is of the most straightforward character. The object has been merely to show the student how to prepare a simple announcement for the printer, and to initiate him into the more simple devices of display. These devices, indeed, are multitudinous in number. The rules and borders commonly found in a printing office can be employed in almost an infinitesimal variety of combinations. The art of creating new and original devices is a matter of experience, and not difficult to acquire. This leads us naturally to discuss the question of pictorial advertising.

Pictorial Advertising. The term "pictorial advertising," for convenience sake, will be regarded in its widest sense, being taken to include all designs used in advertising which have been created by an artist and reproduced by an engraver. A picture or design which has been reproduced by an engraver for printing purposes is known as a "block." In regard to the value of blocks in advertisements there is some difference of opinion. Certain successful advertisers rarely or never use them. Others, again, depend almost wholly upon an appeal to the eye rather than to the intellect—much depends upon the subject.

Varieties of Blocks. A block may be a reproduction of the article or articles offered for sale; it may be symbolical of some idea which is the main-spring of the advertisement; or it may have no relation to the text, being introduced merely to arrest attention. The first case is simple. The block should represent the article accurately, and without exaggeration, and too much emphasis cannot be laid on this point. The symbolical design or picture affords great scope to the ingenuity and imagination of the advertiser. The design which has no relation to the text is the least satisfactory form of pictorial advertising. It may serve to arrest attention, it is true, but it is quite possible that the reader who has been induced to turn from the latest news of the day to the contemplation of a picture of a beautiful woman may experience some measure of disgust when he finds in

the picture merely a device to bring before his notice some prosaic article.

Blocks in common use among advertisers are of two kinds—line blocks and half-tone blocks. For information concerning blocks and their making, see article beginning on page 6481. The advertisement student need not despair if he has no artistic talents—the actual drawing can be done by any artist. It is the *idea* in designs, as well as the text, that commands success.

Newspaper Advertising. With regard to the media in which the advertisement is to appear, the advertiser has an enormous choice—daily and weekly newspapers (London and provincial), and periodicals (weekly, monthly, and yearly); some popular, some devoted to a comparatively select few, others to given objects. The selection depends entirely on the article to be advertised, and the amount of advertising appropriation. Generally speaking, if the article is a popular one, the daily and weekly press are likely to prove the most profitable. This is evidenced by the attitude adopted by most advertisers to-day. Of course, if the amount at the disposal of the advertiser permits, he can go very much further afield, his only care in any case being to ensure a profitable return for his money. Newspaper advertising differs considerably from that of magazines. In the case of the former, it should be remembered that there are fewer and larger pages, and that each page carries a number of advertisements. The advertiser has the choice of an ordinary or preferred position, the latter being next editorial matter, and costs anything from 10 per cent. to 50 per cent. extra, according to the newspaper. Great care should be exercised with the copy intended for ordinary positions, so as to secure a contrast with other advertisements. Very much, indeed, depends on the intelligence of the printer or advertisement office clerk, as the ordinary position advertiser is not allowed to dictate just exactly where his advertisement shall appear on the page. Several successful attempts have been made to print half-tone blocks in newspapers, but the result, at the moment at all events, is not to be entirely relied upon, and more satisfaction can be obtained from line blocks. If a half-tone is used, the screen should not be more than 60.

At the beginning of a campaign especially large spaces are desirable. To the advertiser with a large appropriation and a popular article, they are always profitable. At the same time there are thousands of advertisers doing a good and steady business by the use of small spaces; much depends on the article—much more on the copy. The arguments in favour of newspaper advertising are, shortly: the price per thousand is low; the returns are quick; it covers an extremely large field; it allows of topical advertising.

Magazine Advertising. With regard to magazines, the chief point to remember is that the paper and printing allow of considerable pictorial effect, and this should be taken advantage of to the full. An artistic and striking design should invariably be used, and, other conditions being equal, the result is good. Here, again, it must be remembered that the advertisements are placed together, mostly at the beginning, and some at the end of the book. The front and back covers are obviously good positions, and one or two preferred pages may be had. If the advertiser can afford it, a whole page should be used, and a right-hand one if possible. The arguments in favour of magazine advertising are briefly: it has a long life; it has generally a home circulation; it allows of artistic pictorial display.

Outdoor Publicity. In this branch of advertising the field is very wide indeed, and includes bill-posting, omnibus and tram advertising, railway advertising, boardmen (commonly known as sandwichmen), signboards, and metal plates, window displays, circularising, etc. It is not within the province of these articles to indicate whether any or all of these forms of publicity are profitable. It *is* publicity, and must have some value to that extent, but the advertiser requires a long purse and much patience who invests his money solely in this form of advertising. As a matter of fact he rarely does. Here, again, much depends upon circumstances, and it is yet another instance of the fact that advertising is not "rule-of-three" work. Bill-posting holds the foremost place in outdoor publicity, and is here dealt with. It is unnecessary to go into details concerning the many other campaigns, as they are comparatively unimportant.

Bill-posting. Bill-posting is—and from the very nature of it probably always will be—a most difficult form of advertising to control, and for this reason it is apt to prove expensive. Posters, to be effective, require considerable skill, and no small outlay to produce—twenty thousand double-crown sheets (30 in. by 20 in.), in three colours, costing about £30 to print, in addition to which there is the designer's fee. The advertiser is at the mercy of the bill-posting men, and has, further, to take into account the vagaries of the climate, a bill often being put up one day and destroyed by rain and wind the next. Then, again, the employment of inspectors is generally necessary to ensure that the bills are in position. Much improvement has been noticed in recent years, however, as far as the human element is concerned.

Hoardings are owned by different firms of bill-posters in competition with each other. In London there are between fifty and sixty firms, but in the provincial towns the hoardings are held by one or two men only.

The charge to advertisers is based upon a fixed sum per week per double-crown sheet. This covers the cost of posting the bill (which, of course, is supplied by the advertiser) on the hoardings, and renewing it as often as necessitated by the weather. The rental varies from 1½d. per week down to ½d., and sometimes less. As the same price is generally paid wherever the location may be, it is obviously more profitable to the advertiser to pay greater attention to position than to price.

The most convenient size bills for posting in the United Kingdom are vertical 16-sheet and horizontal 8-sheet posters, the former being 10 ft. high by 6 ft. 8 in. wide, and the latter 5 ft. by 6 ft. 8 in.

Here, as in press advertising, the success or failure of a campaign depends very largely upon the design itself. Poster designing is a thing which an amateur should not attempt unless he combines art of a very high order with his knowledge of advertising. It should be remembered that very little in the way of argument is possible, the design must speak for itself; the passer-by has not always the opportunity, and rarely the inclination, for absorbing argument. What the poster wishes to convey must be conveyed at a glance or it fails in its object.

Posters are used generally to strengthen a press campaign, although instances occur where the advertiser relies solely on this form of publicity. A great advantage of the system is that advertising

can be localised, a consideration to the advertiser who wishes to concentrate his attention to a particular district—a theatrical enterprise, for instance.

Much valuable information regarding billposting and other forms of advertising is contained in "Benson's Facts for Advertisers," published by S. H. Benson, Ltd. (10s. 6d. net.)

Mail Order Business. Mail or post order trading is practised very much more extensively in America than in Great Britain, for one reason because the large shopping centres are far more widely distributed, and but for the mail order advertisers dwellers in remote districts would have to go without many little luxuries that they now enjoy. The system has much to recommend it to everyone but the local provincial trader, who views with some alarm the growing custom of his neighbours to spend money, perhaps hundreds of miles away, that would otherwise find its way into his till. The remedy, of course, is for the local trader to take up mail order trading. [See page 5930.]

The careful student of the advertisement columns of the press will have observed that the popularity of this class of business is increasing. To the aspirant to honours in the advertising field, therefore, the question of mail order advertising is of considerable importance, for, of course, advertising is the basis of the whole business. The watchword of the mail order advertiser should be "now," and his copy must convey that impression to the reader. "He who hesitates is lost," and many an order or inquiry has been lost to the advertiser because of the hesitation of the reader. Goods must be despatched "now," and inquiries answered "now."

Mail Order Advertising. There are three distinct features in mail order advertising—the advertisement; the catalogue; and the follow-up system. The aim of the copy should be, of course, to sell a certain article, or obtain applications for a catalogue. If a comparatively small space is to be used, one article only should be advertised. Particular attention must be paid to the block, which should portray the article in an attractive and pleasing manner, but with absolute truth. The price should be moderate enough to be on the face of it a bargain. Bear in mind that the object of the mail order advertiser is to cultivate satisfied customers—the selling of one article is a small matter—it is subsequent sales to which you will look for business. Every parcel despatched will contain a general catalogue, and such useful literature as you have prepared for the purpose.

The catalogue is the big gun of the mail order trader. It must be well got up, though not necessarily expensive. The blocks must be good and attractive, the type clear, and the arguments conclusive, the whole leaving in the minds of the reader a desire to buy. Bear in mind that you have severe competition from retail traders all over the kingdom. Bluntly, your object is to deprive him of his local trade, to bring that trade to a centre—your establishment.

On the tradesman's window depends much of his trade. Your catalogue is your window. See that it is well dressed. You cannot expect a purchaser to desert his local man without good reasons. See that those reasons are logical and clearly defined.

Save your customer as much trouble as possible; enclose simple self-measuring forms, if necessary, and always an order form, which should require very little filling up; also printed addressed envelopes. In addition to the catalogue, a nicely got-up brochure should be prepared, the object of which will be to interest the applicant for catalogues in yourself, your business, your methods, etc., with illustrations of the premises, different departments, staffs at work, etc. This will create a valuable personal impression. If the public do not know you, they will know *of* you, and it all helps to instil confidence.

The Follow-up System. The follow-up system is brought into use (1) to coax an applicant for a catalogue into becoming a purchaser; (2) to sell further goods to a customer already on the books. The card index system is the only successful method for the purpose [see page 6520]. Below is printed a suggested card for the former purpose.

CARD No. 1.

Name: THOMAS SMITH.
Address: 3, Wentworth Street, Leeds.

No. 1.	No. 2.	No. 3.	No. 4.	Remarks.
1/7/07.	8/7	15/7	22/7	

The card shows to exactly what use it should be put. The details can, of course, be altered to suit individual trades, the one given being intended to illustrate the method. The card should be kept under forward dates, so that as each date comes along the second or third follow-up can be despatched. For instance, the catalogue is despatched on July 1st, the date is entered on a card which is put into a date file under date July 8th. The date file is examined every morning, and July 8th is reached automatically. Follow-up letter No. 2 is then despatched, the date marked on card, which is then put forward to, say, July 15th, and so on. At the end of your system you will have either secured an order, or given the applicant up as hopeless.

Follow-up Letters. There are divergent opinions as to the length, number, and character of follow-up letters; but there should be no two opinions as to how they are turned out. The letters are a personal matter between the advertiser and his correspondent, and should be written in a personal strain—as a *letter*, not a circular. To be effective, it is well to let the recipient think that your message is to him, and him only. With the up-to-date mechanical appliances now on the market, it is a simple matter to type in a name and address to match the body of the letter. Above all, the signature must be an autograph. A print, litho, or rubber stamp deceive few people nowadays. The employment of a few girls to autograph letters will well repay the outlay.

The object of the follow-up letter is to establish personal relations—to put you on calling terms, so to speak. The letters must be consistent and continuous as to contents, and with increasing insistence, but not to the point of causing annoyance. Letter No. 1 is sent to cover catalogue, draw attention to the comprehensive character of the book, and suggest that recipient will find what he requires within its pages. In letter No. 2 trust that catalogue was safely received; assume correspondent undecided as to making purchase, although full particulars given of articles similar to that described in original advertisement upon which application for catalogue was made; dilate

a little on prices and quality, and hope to hear by return. In letter No. 3 express regret at not having heard; ask if there is any further information required; suggest as goods are seasonable lines will shortly be out of stock, and will not be replaced: that it is a good opportunity to test value given at the emporium, the cost of the particular goods being so small: the cold weather will shortly be setting in; has correspondent noticed the bargains in warm underclothing (or other topical allusion). In letter No. 4, after referring to correspondence, point out in strong sentences that goods are guaranteed to be as described, will be sent on approval—carriage paid; that you please thousands of customers weekly, and have no reason to think cannot please correspondent. Perhaps particular requirements are not listed; catalogue of other departments enclosed. Try another topical allusion.

The above are given to show the idea, and are probably more or less commonplace in themselves. The follow-up letter gives unlimited scope for the display of individuality, and on this quality depends the success of the attack.

Each successive transaction should be noted on card. These cards should be examined periodically to see if the customer has ceased to do business, and should this occur, as, of course, it must in time, a little follow-up series should be sent asking reasons, etc., and card should be taken from active file. This will avoid waste of postage, catalogues, etc., through sending to people who have removed.

CARD No. 2.

Name: THOMAS SMITH. *Folio.....*
Address: 3, Wentworth Street, Leeds.

	£	s.	d.		£	s	d.
3/8/07	3	2	6				
16/9/07	1	3	4				

Tracing Results from Advertising. This is technically known as "keying." A key is a special mark, appearing in the advertisement which, when answered, shows at once the medium which produced it, and it can be extended to show the particular copy used.

Presuming the name and address of the advertiser is W. A. Baxter, 14, Fenchurch Street, London, E.C., variations could be made as follows:

H. A. Baxter (a different initial for each paper), or—

W. A. Baxter, 14A Fenchurch Street (different letter to number), or—

W. A. Baxter, Dept. A., 14 Fenchurch Street (different department letter).

Different combinations can be used to distinguish particular copy. Every envelope containing an order or application for catalogues should be scrutinised for distinguishing signs, and a careful record kept in a book ruled as follows:

FOR CATALOGUE APPLICATIONS (left of book).

Date of issue.	Space of Advt.	Medium.	Copy used.	Number received.	Cost of Advt.	Average cost per application.	Subsequent value of sales at end of follow-up system.

DIRECT SALES (in right of book).

Number of sales.	Total value.	Average cost per sale.	Cost per £100 of sales.	Remarks.

A most reliable clerk should be placed in charge of the book, and the advertiser, or his advertising manager, should watch it closely. Directly a medium fails to produce profitable results, a strict inquiry should be made and, if necessary, the offending sheet cut off at once.

General Advertising. The advertiser who trades through the retailer invariably, at the beginning of his campaign, backs his advertising with a "selling" scheme in order to get his goods stocked. As a particular selling scheme is rarely used more than once, there is no object in dealing with the subject here. Such schemes can be thought out only after careful consideration of the conditions governing the particular trade in view, and the advertising man who can originate and carry through a good scheme is eagerly sought after, and commands a high remuneration.

At the beginning of a campaign the press advertising should be of an educational nature. A series of talks on the why and wherefore of the goods, written in good telling language, and set in plain, easily-read body type with little display besides the heading. The pictorial designs and fancy borders will follow after to serve as continual reminders. It should be remembered that designs consume much space, and only a little letterpress can be included—see that that little is good and to the point. It is impossible in the space at our command to give further specimens of advertisements, or examples of copy-writing. The student has the whole of the press before him to use as text-books, and a study should be made of the announcements put out by the many prominent advertisers of to-day. A habit of advertisement reading should be cultivated, and close study will soon indicate the line to be adopted.

To Obtain a Position. As in other walks of life, luck must enter somewhat into this matter. On leaving school, and especially if influence cannot be brought to bear, the young man is often obliged to take the first promising berth that is offered to him, but he can influence his destiny very much by continually being watchful for an opening elsewhere. If he has a gift for copy-writing little difficulty need be experienced. In these days copywriters are in great demand, but the work must show signs of genius to earn appreciation. A good plan is to study as far as is possible from the outside the business of different advertisers, and to submit the advertisement personally. The common mistake should be avoided of putting a price on one's work until it has been accepted. In the case of a mail order proposition the advertisements should be offered on the "no cure no pay" principle—that is, if the advertisements fail to produce results they are not to be paid for. An offer of this kind will create confidence, and should the designs be successful more will be requested.

BUSINESS MANAGEMENT *concluded*

THE STAGE AND SPORTS

The Making of an Actor. Qualifications. Enunciation and Gesture. Making-up. Playwriting. The Business Side of Amusement. Sport Officials

Group 22

BUSINESS OF AMUSEMENT

Following MUSICAL INSTRUMENTS from page 6714

THE STAGE

Broadly speaking, actors resemble poets in that their gifts come direct from nature, and only to a limited extent is their art a thing of schools. There are many critics, of course, who object entirely to the word "art" being applied to acting, and it is no doubt true that any art which relies so much on the physical personality of the artist is not entitled to rank high; but, with this limitation, a good case may be made for the art of acting. We have here, however, no space for academic discussion, and must confine ourselves to a very brief and practical consideration of the qualities necessary for success on the stage and the means whereby these may be brought into use.

The Efforts to Teach Acting. Schools of acting innumerable have had their little day and ceased to be, from Macklin's school, whence came Foote and Dr. Aaron Hill—who also tried to found an "academy"—and Sheridan's more ambitious, but more visionary, "oratorical academy," to the different projects associated with the name of the late Sir Henry Irving. Doubtless, long before Macklin and Sheridan, enthusiasts set up dramatic schools, and long after the present generation has disappeared enthusiasts of the future will be wasting their time at the same futile business. For there is no gainsaying that the only good school of drama is the stage itself. It is true that on the Continent dramatic teaching has long obtained, but the best judges are agreed that the methods of the Théâtre Français applied in England would do more harm than good. It is all in the best interests of English acting that the notion that an actor can be taught should be consistently discouraged. There is, perhaps, no calling for which the impulse must be accompanied by natural aptitude to the same degree as that of the actor; and we would have the aspirant understand, in the most unmistakable manner, that, lacking this, no amount of hard work, no amount of intellect, will help him to success; and, equally, possessing it, success is most elusive and less to be reckoned upon here than in any other profession, while, once secured, it is more difficult to maintain.

It is true that in the case of women, good looks and a commanding figure may help in these degenerate days to secure success on the stage. We have in mind at the present moment a lady whose name is familiar among the eminent actresses of to-day, whose photograph is vastly popular with collectors, who is never out of an engagement, and, beyond looking handsome, and walking across the stage with some degree of gracefulness, she is utterly destitute of the slightest dramatic ability. There are others in like case, and the serious student will have these awful examples always to remind him or her that there is something rotten in the state of the stage!

Adult Acting and Child-play. The natural gifts that are essential to good acting have been in the possession of each one of us, but we have not all succeeded in retaining them. The dramatic instinct is born in every human being; a great deal of child-play is essentially acting, and excellent acting sometimes. But most people, as they leave their childhood behind, leave with it the land of make-believe, become self-conscious, and cannot *at will* subordinate their own personalities to those of imagined characters, which in childhood they had done almost as an act of faith. The actor has to be consciously unconscious, so to speak; he has *consciously* to imitate the gestures and attitudes which, in a child, are the result of no artistic effort; he has to be as "natural" as the child by means of consummate art; he has to *appear* to believe in fictions of the brain in which the child actually *believes*. This faculty, which is far more rare than people are apt to think, is somewhat vaguely defined as "dramatic instinct." It follows, therefore, that a technique of acting can only begin by assuming the presence of this faculty, and in its absence all is vain.

The Essentials of Good Acting. Assuming that the aspirant has dramatic instinct, which involves a natural feeling for the display of emotions, a ready sympathy for the distinguishing traits of character, and the power of expressing feelings with some dramatic conviction, there remains much that may be done by study, and something also by instruction, in order that the dramatic talent may be developed to the fullest extent. Lloyd, in his poem, "The Actor," very justly observes:

> "To this one standard make your just appeal,
> Here lies the golden secret: LEARN TO FEEL.
> Or fool, or monarch, happy or distrest,
> No actor pleases that is not *possessed*."

But even so, the poet points out further on that feeling is not enough:

> "The player's province they but vainly try
> Who want these powers—Deportment, Voice,
> and Eye."

That is to say, having derived from nature the great and essential gift, one must turn to art for the means of applying that gift to the best advantage.

The Actor must "Feel" His Part. Perhaps feeling might be given forty points, and all the other qualities together, sixty; but feeling is precisely the quality in which the ruck of our actors are deficient. It alone can give intelligence and consistence to the reproduction of a character on the stage or the interpretation of a sequence of emotions. "I cannot simulate suffering without an honest sympathy with it," says Mrs. Bancroft. "I hold that without great nervous sensibility no one can act pathos; it is impossible to feel the sentiments one has to utter, and but half the author's meaning can be conveyed. It is a casket with the jewel absent. The voice in emotion must be prompted by the heart, and if it is 'out of tune, and harsh,' why, then indeed, the voice is 'like sweet bells jangled.' Art should help nature, but nature must help art." The celebrated actress puts the matter very clearly in these words, which indicate that a deep and abiding interest in one's fellow-creatures is an essential characteristic of the good actor.

Studying Others and Ourselves. "The proper study of mankind is man," and assuredly this is a maxim that must ever be in the mind of the actor. Not only must he study and sympathise with his fellow-men, but, as Lewes remarks in his classic on acting: "We are all spectators of ourselves; but it is the peculiarity of the artistic nature to indulge in such introspection even in moments of all but the most disturbing passion, and to draw thence materials for art." This is well illustrated in the confession of Talma, the great French actor, when he says: "I have suffered cruel losses, and have often been assailed by profound sorrows; but after the first moment, when grief vents itself in cries and tears, I have found myself involuntarily turning my gaze inwards, and found the actor was unconsciously studying the man, and catching nature in the act." It is thus that great acting becomes possible. A tailor's dummy or a dressmaker's model would be quite sufficient to study for many of the actors and actresses who cumber the English stage to-day.

Given great natural gifts of sensibility, a rich, passionate nature, strong sympathetic voice and expressive features, but above all an utter absence of self-consciousness, it is surprising how physical defects may be overcome. Many famous actors, such as Betterton, Garrick, and Macready, triumphed thus over physical inequalities; but a pleasing personality is also greatly to be desired, though beauty of feature is by no means essential, as it is notorious that most of the great actresses have been plain women: and in the strong light of the stage a plain woman often looks better than one who is naturally beautiful. This, however, touches the question of "make-up," at which we shall arrive in due course. Of first importance after the qualities we have already mentioned is the art of speaking. It is doubtful if there is a people, other than the Americans, who speak, on the whole, more slovenly than we English do. Speech is an art that has been all but neglected among us. Here, our stage is immeasurably behind the French stage, and this is one of the elements of the actor's art that can be taught.

Elocution or Effective Speech. Some there are to whom a clear and effective manner of speech, with a good range of voice, which almost unconsciously they can pitch to suit the hall or theatre they are speaking in, has come as a direct gift of nature. But they represent a very small minority, and it may be taken that most aspirants to the stage or platform, however good their natural speaking voice may be, would be the better for a thorough course in elocution or voice production. Into the matter of elocution the personal equation enters so largely that it is not possible to lay down any hard and fast rule which would be of equal service to all beginners. That might be done, and has, indeed, been done, with some measure of success in a long treatise, but nothing can quite take the place of a course of study with a master, who is watching every characteristic of the student, correcting his faults and leading him gradually to the full exercise of such powers as he possesses. Provided the student is already endowed with the histrionic qualities enumerated above, a course of voice-production might with advantage take the place of the ordinary lessons in elocution, as there is a tendency in the latter to leave the student with some mannerisms acquired from the master, and this, unless it is strenuously resisted, may be disastrous.

While we are all for the "natural" in acting, it is imperative to remember that natural acting is not the mere reproduction of everyday speech and gesture. Heaven forbid! Shakespeare's plays hold the mirror up to Nature in a way that is at once the admiration and despair of all modern dramatists; yet his characters, throbbing with human passions, are made to declaim their emotions in blank verse such as no human being ever spoke in actual life. Here is the poet's art; he enthralls us with the beauty of his diction and the reality of his creations. So should the actor aim at perfection in his speech, which, carefully studied and polished, will bear no absolute resemblance to the ordinary speech of daily life, but will yet, by its charm and natural delivery, produce in the audience the agreeable feeling that it is "true to life."

Importance of Emphasis and Pause. After having understood his author—which is, of course, the first duty of the actor—he must next make clear his author's meaning, for, as Tennyson says, "Words half reveal and half conceal the soul within." A word may be made to convey just as much or as little as the speaker determines; hence the need for him to know precisely what he wishes it to convey. Thought must precede and regulate the utterance. "Emphasis and pause," says Lewes, "are, indeed, the supreme difficulties of elocution. They are rarely managed by those who read blank verse, even in a room, and on the stage the difficulty is greatly enhanced. Nevertheless, no one can pretend to be an actor of the poetic drama who has not mastered this art, although in the present day it is like many requisites, badly disregarded, and we hear the noblest verses spouted (not spoken) with the remorseless indifference of the actor who announced himself thus: ''Tis I, my lord, the early village cock!'" Colley Cibber also observes justly that "the voice of a singer is not more strictly ty'd to time and tune than that of an actor in theatrical elocution."

Life and Spirit of Good Speaking. Canon Fleming, in his excellent treatise on "The Art of Reading and Speaking," illustrates very effectively the importance of proper emphasis thus: "On the right management of emphasis depends the very spirit and life of good speaking. If no due emphasis is placed on any words, not only is our speaking heavy and lifeless, but there is no intelligent meaning thrown into what we speak or read. Let us take a simple question: 'Do you ride to town to-day?' These six words are capable of no fewer than four different meanings. If pronounced thus, 'Do *you* ride to town to-day?' the answer may be, 'No; I intend to send a messenger in my stead.' If thus: 'Do you *ride* to town to-day?' the answer may be, 'No; I intend to walk.' 'Do you ride to *town* to-day?' 'No; I intend to ride into the country.' 'Do you ride to town *to-day?*' 'No; but I shall do so to-morrow.' Thus the whole force of an expression may depend on a word, and we may give our hearers quite different views of the same sentence by placing the emphasis differently."

It may be thought that these niceties of detail are scarcely necessary where one has mastered the sense of the words to be spoken, but that is as great a mistake in acting as depending upon "the inspiration of the moment," which Lewes very happily likens to trusting to a shipwreck for one's first lesson in swimming. Perhaps the crowning difficulty of elocution, which nothing but constant practice will overcome, is the need to be slow while not seeming slow, "to speak the phrases with such

distinctness, and such management of the breath, that each shall tell yet due proportion be maintained," as hurry destroys all effect, and is the hallmark of the incompetent actor. Even Garrick in his early days had not attained proficiency here, and, having failed to study his breathing, came near to spoiling his greatest scene on his first appearance. On the whole, we urge the aspirant to stage honours to make a most careful study of voice-production.

Gesture on the Stage. Following the mastery of the art of speaking, and intimately associated therewith, is the consideration of gesture. Here, again, our national characteristics have to be overcome, as there is so little natural grace in the gestures of English people that on the stage actors are apt either to be deficient in gesture or to overdo it. Hamlet's address to the players is the supreme classic of advice on the subject, and there it will be remembered the actor is advised to "suit the action to the word," but equally "the word to the action." He is also warned against excessive gesticulation in these words: "With this especial observance, that you o'erstep not the modesty of nature; for anything so overdone is from the purpose of playing." A visit to almost any London theatre to-day will show that, impeccable though Shakespeare's advice undoubtedly is, surprisingly few have profited by it. The annals of the stage from Betterton to the present day are full of stories illustrating the errors of even great actors in the important art of gesture. When one reads, for instance, of the extravagances of Quin, it is difficult to understand how he came by his reputation.

Even Garrick never quite conquered the art of "repose on the stage," and Macready only achieved it by the most rigorous training, such as reciting violent scenes from Shakespeare's tragedies with his arms bandaged, so that his tendency to overgesticulate might thus be overcome. "The easier an actor makes his art appear, the greater must have been the pains it cost him." Let all aspirants bear these words of Macready in mind. We have seen many books illustrated with numerous diagrams purporting to teach the whole art of gesture, but we cannot recommend any, and, except certain rules for walking upon the stage, which may be imparted to the student or acquired by him from observing graceful actors, there is nothing that can be set down in writing beyond the words of Shakespeare: "Let your own discretion be tutor," and "do not saw the air too much with your hand." Of course, all exercises of the limbs, such as calisthenics and dancing, should be undertaken by the would-be actor, as they tend to impart grace and suppleness of the body, and if there is an intelligent mind controlling that body, the result cannot help being satisfactory.

Costume and "Make-up." We come now to the question of making-up, but can only touch upon this in the briefest possible way, as nothing but experience gleaned from "old stage hands" will help in the details. It is an art in which the modern stage is vastly in advance of the days of Garrick or Macready. Actors of our generation have largely thrown off the traditions that used to rule in the matter of costume and make-up. For generations Shylock was played in a red wig. Edmund Kean was the first to break this tradition, which originated from the belief that Judas was a fair Jew. Macready was probably the last to observe the old custom of wearing a plume of feathers, long thought to be indispensable to the leading figure in a tragedy. The red wig still lingers in the make-up of the country bumpkin, but, broadly speaking, the stage is now rid of all stupid conventions in the matter of costume, education and travel having made such inappropriate dresses as Garrick wore in Shakespearean parts and foreign characters quite impossible. Thus, in the matter of costume no advice beyond the dictates of common sense and historical accuracy is required; but in the make-up of the face there are still many actresses, though chiefly those of no importance, who require to be reminded of these words written by the late Lady Martin (Helen Faucit) many years ago: "When the skin is covered with what is in fact a painted mask, the colour, which, under strong emotions would come and go, is hidden under it, and the natural expression of the countenance destroyed."

Prospects of Success. Having every qualification for success on the stage, the aspirant may still find himself faced with nothing but failure. As already hinted, it is not always genuine ability that leads to success, but we have not the space here to deal with the varied causes which make the life of the player a greater lottery, and, on the whole, a source of less satisfaction than that of any other professional. The theatrical world swarms with undesirables, with harpies, and with sharpers; and the path of the aspirant is, in consequence, full of pitfalls. The real tragedies of the stage-door are often as poignant as, and infinitely more numerous than, the mimic tragedies of the stage. We can, therefore, only advise aspirants to act with the greatest possible caution in any dealings with "theatrical agents," and to endeavour rather to get into touch with the managers of provincial companies.

The Best Fields for Aspirants. Time was when the avenue to success was clear and unobstructed to all who had the talent. That was in the old days of the stock companies, when in all the large towns theatrical managers employed permanent companies of actors who could support any "star" from London in whatever repertory he or she chose to give the local playgoers. These stock companies, and the old "circuits," were the training ground of the Victorian stage, and produced many of our most famous actors, not a few of the "older hands" of the present day having graduated from them. But, unhappily, the modern system of flooding the provinces with "touring companies," that merely give imitations of London successes, has ruined this most excellent training ground for the stage. An actor of very limited ability can pass muster for a few years, and possibly have an enjoyable life meanwhile, as an intelligent parrot, repeating to provincial audiences imitations of London acting; but this is not training nor experience worth having for the serious aspirant, and in the end it is a very poor life indeed. There are a few repertory companies, such as Mr. F. R. Benson's and Mr. Ben Greet's most excellent Shakespearean and "old comedy" companies, that provide the young actor with a good substitute for the stock companies; and proof of the value of such companies, which tour the provinces with considerable repertories, changing their bill almost every night during a fortnight, is seen in the fact that many of the leading actors on the London stage to-day have been trained in these repertory companies. It is to companies of this kind, where, instead of playing the same piece for three years on end, the young actor will have constant and refreshing change of parts, that the aspirant should direct his attention. Needless to say, the amateur dramatic society is a most useful first step

in the direction of a stage career, and enables a person of sense and sensibility to ascertain whether or not he has any aptitude for the art.

We cannot but confess that, if asked to advise anyone on the adoption of a stage career, the person of discretion with knowledge of the theatrical life is bound to say that if one can find profitable occupation in any other branch of work, one would do well to leave the stage severely alone, and to young women this applies with especial emphasis.

Playwriting. Here we can only touch very briefly on the subject of playwriting, as it is not at all probable that any student of the SELF-EDUCATOR will look to it for assistance in the writing of a play. Although we have many examples to the contrary, there is little doubt that a practical knowledge of the stage is of great importance to the dramatist. Mr. Pinero, Mr. Jerome, Mr. Brandon Thomas, and many other successful dramatists, have begun their careers as actors. It is worth while remembering that many of the Elizabethan dramatists, including Shakespeare himself, were actors also. The ability that makes of a man a successful novelist might be of very little value to the making of a playwright; but the income that can be earned by a popular dramatist is so great that there are few novelists of note who have not made a bid for stage success, and not one in a score has succeeded. If one has the ambition to write stage plays, it would, therefore, be well to secure some practical knowledge of the stage in any sort of company as a preliminary step. But so far as the actual writing is concerned, we fear that only a laborious study of published plays—classic and modern—will help to a mastery of technique, and after that there is a pressing need of some original inspiration. Given the latter, one might succeed even with bad technique, but without it the best technique in the world could not prevent failure!

THE BUSINESS SIDE OF AMUSEMENT

By ALGERNON ROSE

The degree of enjoyment is governed by the capacity to appreciate. Thus, the habitual theatre or concert-goer in a city becomes more and more critical. He is not content unless the performance possesses artistic excellence. In small provincial towns people are less fastidious, and audiences welcome less accomplished performers. Great talent, as long as it draws, may, in a big town, demand its own terms; but mediocre ability must take what it can get.

Acrobats. The term acrobat applies chiefly to equilibrists, contortionists, and trapezists. Since 1894, the law in England has prohibited the training of children as acrobats before the age of sixteen, except by their own father. Trainers, in consequence, have removed chiefly to Brussels and Antwerp. There, children of tender years are put through many cruel exercises in order to give abnormal flexibility to their bones and muscles. Acrobatic talent often runs in families. The members will practise perseveringly together and work at certain tricks for many years before exhibiting in public. This has been the case with the famous Craggs—the father, who was self-trained, teaching his five sons and one daughter many extraordinary feats.

There is as much difference between an ordinary tight-rope dancer and such finished performers as the Craggs as there is between a "pianist" who "vamps" an accompaniment and Paderewski. While the remuneration in one case may be 5s., in the other £50 a night may not suffice. In this class of entertainment, certain names stand out above all others, even as those of a few musicians appear as Tritons amongst thousands of struggling minnows. There were possibly many acrobats able to balance themselves as well as Blondin. He was recognised—they were not. In like manner Leotard could ascend and descend an immense spiral, balancing himself on a large ball. He obtained a vogue, and a consequent bigness of salary which others failed to get. Amongst many clever jugglers with inanimate objects we find the personality of Cinquevalli eclipsing that of his rivals, and his dexterity in accomplishing the apparently impossible exciting the interest of vast multitudes.

Trapeze Work. When we come to trapeze work, the names of the Leamys are remembered everywhere. Although the safeguard of the net has made such performances less dangerous than they were, emulation has increased proficiency. The best trapeze work of to-day excels that of twenty years ago. Trick bicycle riding, balancing on the back in Japanese fashion, equestrian feats, and strong-man business, if remunerative, depend not alone on perseverance, daring, and ability to do what is undertaken, but on the gift possessed by the performer, or leader of the troop, to convince those who give engagements that the entertainment offered will attract powerfully and more than justify the terms demanded. The "management" of a hall have an unsympathetic way of regarding art. They estimate the precise amount in cash that each turn will "draw." This applies equally to the greatest concert performers. From a business point of view, Caruso or Melba are "good for" so much. It is a mathematical problem. Reckoning 21 in. as the space each person in the house will occupy, if a certain star will "draw" a specified number of people, and the auditorium "holds" a given sum, the fee to leave a tangible profit cannot exceed a certain limit unless a larger building is taken and a greater risk incurred.

Advertising. It is well known, in dealing with the commercial side of amusements, that the cleverest artist frequently possesses least aptitude in financial negotiations. If he gets big terms he is indebted for them to the ability of his agent. Where, however, as in the case of Sarah Bernhardt or Adelina Patti, artistic and commercial talent are almost equal, the way in which the former is aided by clever réclame considerably enhances in public estimation the status of the individual. The study of the public performer who receives big fees is how constantly to attract the notice of those who pay willingly high prices for admission. Such is the contrariness of human nature, that it is a truism to say, "Once convince the public that they cannot get into an entertainment, and they will clamour for admission." But it should not be forgotten that if inadequate ability is "boomed" unduly, it frequently means disaster to the artist.

To turn to early engagements, the young professional, if without other means, must contrive to live by fees received from pupils. Without experience as a teacher, he cannot at first demand his own terms. Yet, the axiom, "do as you would be done by," should be remembered. It is not chivalrous to declare that a neighbour's system of teaching is wrong and to offer instruction at half-price. When there are other children not being taught, it is despicable to "poach on the preserves"

of a fellow professor by underselling him. In past years professional jealousy has done much mischief to the interests of musicians as a body. To counteract such tendencies, the Incorporated Society of Musicians was formed, membership being confined to properly qualified candidates. In many ways, the society is most helpful to those embarking on a career. The young professional, therefore, cannot do better than seek election as a member. It will bring him in touch with the right people, and differentiate him from certain bogus teachers who advertise lessons at 2s. 6d. a course, or 3d. each. They are dear even at that sum.

To make a beginning, it is advisable to have a neat circular printed and sent to the most likely addresses given in the local directory. More effective than printed matter is, however, personal recommendation. In return for assistance given at charitable performances, the clergyman, organist, or other officer of the place of worship attended by the young musician, can often assist him materially. In order to get one's name into the programme and become known, there need be no scruple in offering to assist at a boná-fide charitable entertainment. At a time of life when the enthusiast is most impetuous it may be difficult to wait in hope of engagements to come; yet it is waste of energy to badger acquaintances in a tactless way.

Getting Known. The young professional should be contented with a little at first and devote his energies to practice and composition rather than spoil a favourable impression he may have made by declaiming against those who happen to be more fortunate than himself. If, presently, he obtains two pupils a day at 2s. 6d. an hour they will bring him in 30s. a week. This is more than many a young physician, after a far costlier training, earns in the first or second year of his professional life. The physician may not advertise any more than a member of the Stock Exchange; but the musician has no such restriction. Nevertheless, he must be careful not to indulge in any advertising which looks vulgar. If he desires, ultimately, to win the favour of cultured people, he must strive to keep up the dignity of his profession in all that he does.

The biographies of most of the great virtuosi show that before becoming famous they had to go through the drudgery of teaching unmusical pupils, however galling it may have been to them. As a rule, the life of the great executive artist begins with teaching reluctantly. But it ends with imparting experience whole-heartedly to pupils of his own choice. Keen on getting recognition, the talented young singer or player endeavours to procure a minor engagement in a company making a provincial tour. This may be fixed during the summer vacation, when the company may visit various seaside resorts. As his pupils are then taking holiday, permanent teaching will not be lost.

Touring. As with theatrical touring, a concert tournée requires good health on the part of every member of the company. If the tour is to pay, to get from one town to another in a given time may necessitate frequent night-travelling. Sometimes, on arrival at a destination, it may be necessary to proceed immediately to the concert-room without a meal. If the rough is taken cheerfully with the smooth, and the manager of the tour is honest, when it is ended unpleasantnesses will be forgotten and the change remembered happily.

During a tour the young musician should collect carefully any favourable allusions to his performance in the local papers. Printed subsequently as "Opinions of the Press," such testimony will carry more weight than the most conscientious self-praise, or even certificates won at a music school. Possessed of a number of newspaper notices, his plan—if he is a solo singer or instrumentalist—is to send his circular to the secretaries of various societies, in the provinces or London suburbs, mentioned in the Musical Directory (Carte, Berners Street, W.), in which he should be careful also to have his name entered. Personal appearance being of equal importance on the concert platform as on the theatrical stage, it is customary to have a photograph printed on the front of the circular. These may be taken also to the music shops or music publishing houses, the latter being requested to send professional copies—if the musician is a singer—of any songs they wish made known. It is the experience of publishers that, if a new song is encored at a concert, its sale is increased. For that reason the services of a good singer are recognised by the payment of a small fee for each public rendering. The singer forwards copy of the programme as a voucher.

Paying for Appearances. The pressure of young artists to obtain a hearing in a limited number of influential concerts is nowadays excessive. Ambitious performers, possessing private means or well-to-do friends, have become, therefore, easy victims of unscrupulous concert agents. By this it is not inferred that all agents are dishonest. Those of reputation, who act on behalf of established favourites, seldom concern themselves with artists seeking recognition. But a new and less scrupulous "Concert-Direction," on being established, will often send circulars to young musicians requesting a visit. A critical hearing is given, as well as sympathetic advice. It is pointed out that to hide such light under a bushel is wrong. To achieve success a concert must be given, to which the musical critics will be specially invited. The agent undertakes to hire the hall, engage attendants and artists to assist, to print tickets, programmes, and see to the advertising. An estimate is given. If beyond the means of the aspirant or his friends, the sum is reduced. A substantial deposit being paid in advance, the concert takes place.

As space is valuable in the daily papers, the critics do not attend. Minor journals may insert paragraphs supplied by the agent, or even detailed comments. These are of little worth. According to the gullibility of the victim, so is the length of the bill. The artists who have assisted, and whose fees are specified in a lump sum, may, individually, have paid for the privilege of appearing. Yet, in a business sense, the agent may have acted honestly in regard to the items for the hall, printing, and advertisements In any case, the money is lost so far as the artist himself is concerned. Whether at bogus or boná-fide concerts, the system of paying for appearances is wrong. Conspicuous talent, providing that it exists, cannot for ever remain unrecognised.

The Theatre. Successful theatrical speculation involves considerable capital. The actor-manager, who takes the financial responsibility upon himself, has an exceedingly anxious time. Not only have suitable premises to be leased and staffed by a small army of workers, but if the piece put on is a new one and musical, unless the manager has a will of his own, what with the interests of the librettist, lyric writers, composer, singers, and actors to consider, little progress will be made. When we hear of one artist receiving £100 a week, another £70, and another £60, it may surprise the

amateur to be told that, on the authority of a London magistrate, well acquainted with the subject, an actor's average is not more than 35s. a week. What many members of the profession, therefore, desire are "smaller salaries and larger incomes." It is, of course, better to receive 35s. a week regularly than to play in a piece at £30 a week which runs less than a month, the cost of dresses being deducted from salary, and, after rehearsing gratuitously for six weeks, "resting" the other ten months in the year. For rehearsals there is no pay. These sometimes go on for months. In a few London theatres salaries are now paid during the last fortnight.

Opera Companies. One opera company advertises that chorister-pay per week is for tenors, £2 7s. 6d.; baritones and basses, £2 5s.; sopranos and contraltos, £2; extra salaries being given for small parts played by the chorus.

To many aspirants such terms may appear attractive. It by no means follows that the amounts advertised will be received. When a personal trial is given, the manager may consider the quality of voice, or ability to act, falls short of his standard. In certain choruses, instead of receiving salaries, novices have to pay for appearing in minor parts to get experience. In a West End theatre a stage manager (not actor-manager) may get £10 a week for much hard work, having to be in the theatre from early morning till late at night. The stage-carpenter will probably receive £3 a week. This he supplements by perquisites; otherwise there might be no limelight to spare for the lesser stars. In certain theatres the conductor of the orchestra receives £12 a week. Daly's band alone costs over £200 a week. Some of the players in this band possess violins valued at more than £50 apiece. A West End box-office keeper receives £6 a week, and his assistant £3. Programme-sellers and cloak-room attendants get 3s. a night, and the supers 1s. 6d. In the provinces half West-End prices are paid. The aspirant who has taken part in amateur theatricals and become stage-smitten finds the glamour dissolve when coming to the practical side of theatrical life.

The Dramatic Agent. Engagements are solicited through the dramatic agent. His office in London is either in the Waterloo Bridge Road, a turning out of the Strand, or in the purlieus of Shaftesbury Avenue. The hours are from 11 a.m. to 4 p.m. Contingents of unemployed, sometimes in poorest attire, wait their turn to hear if engagements can be found for them. On a name being entered, a small fee is paid. If an engagement results, 10 per cent. or more is charged on the first year's salary. Without interest, the chance of getting into a good touring company is nil. All that can be hoped for is that the tour will be genuine. There are few actors who have not experienced being stranded a long distance from home in their early days when a tour has collapsed. If the company is boná-fide, an engagement, including travelling, seldom yields more than 30s. a week. Out of this, board and lodging have to be paid and sometimes dresses provided. In case of illness no margin remains. There may be a fatiguing journey in the morning, a rehearsal in a strange place all the afternoon, prior to the performance the same night. After that it may be necessary to search for lodgings, unless these have been secured in advance. Add to these troubles the rivalries and jealousies of stage life, and it is a marvel that "mumming" should continue to attract so many victims.

Pantomime. The manager relies chiefly nowadays on scenic and spectacular effects. Large sums of money are lavished on the mise-en-scène, often at the expense of the salaries of the majority of the company, just as, in grand opera, the chorus may be starved in order to provide big fees for a few stars. After long gratuitous rehearsals, ladies of the ballet receive 25s. a week. But their dancing is not comparable with the highly-trained terpsichorean skill of the prima ballerina, whose salary will be £30 or £40 a week. The principal boy may receive £10 a week. The first clown will probably get £20 a week, the harlequin and pantaloon receiving £5 each, whilst an ordinary knockabout has 30s. The harlequinade, which used to be the chief pantomime attraction, is now relegated to the end. In the days of Joseph Grimaldi, his genius brought the clown into great prominence. Since his time there have been no men of similar ability in his line, and the clown no longer draws in the same way.

Music Halls. A comic singer, doing three or four halls a night will receive, according to his ability, from £10 to £40 a week. From this he has to deduct the hire of a conveyance from one theatre to another. Only exceptionally gifted artists command their own prices. Dan Leno, working four halls a night, made over £200 a week, but the excitement killed him. A well-known serpentine dancer in ever-changing colours received £20 a week. A troupe of good acrobats may get £50 a week, whilst débutants who have not yet made a name, may only receive £7 between a troupe of seven. A wrestler will get about £20 a week, as well as a purse, if successful. Unknown performers are paid nominal sums on short contracts, and are put either at the beginning or end of a programme. Should the "turn" score a success, they are then at liberty to demand higher fees and receive longer agreements. As long as they are capable of drawing the amount asked, the management is not likely to let them go elsewhere. After some years of minor engagements, a husband and wife, making a prodigious "hit" in so-called "thought transference," are receiving £500 a week because they draw more than that sum.

Circuses. Whether in town or country, the chief care of the circus manager is his stud of horses. These are often of great value. An intelligent performing horse may be insured for £1,000 or more. Besides these, the manager has always a plentiful supply of daring riders. As there is an excess of young men desirous of breaking their necks in public, the fees paid are not high. The English horseman, being superior to most foreigners, it is often possible to get more lucrative engagements on the Continent than in this country. Here the riding-master may get £5 a week; principal equestrienne, £20 a week, and the principal horseman, £30.

Conjurers. West End ticket agencies or libraries do considerable business during the season in supplying all sorts of artistic talent for bazaars, juvenile parties, or social functions. As a rule the agent deducts 10 per cent. as his commission from the fees paid. Sometimes an agent will make an exclusive arrangement for the services of an artist who cannot himself obtain engagements. A clever conjurer known to the writer found it to his advantage to make such a contract with a firm in Regent Street. A brougham was in waiting for him every evening. During the fashionable season he was driven off to different aristocratic houses. There he gave a two hours' entertainment of sleight of hand, ventriloquism, and so forth. After having supper, he was driven home. For this he received

£6 a week. Beyond drawing up his programmes, he had no correspondence to attend to.

In this case, when charging a fee of ten guineas for a performance which cost only £1, the agent often made a big profit. Nevertheless, the entertainer was contented with his bargain. He had no expensive premises to maintain, and although skilled in his peculiar way, had no ability to make negotiations direct. So far as he was concerned, as long as he was in good health and able to entertain, he had a sure income of over £300 a year. If his agents occasionally made a large sum, it was their speculation and not his. But between the conjurer of average ability, who may get £1 a night, and a phenomenal prestidigitator like the late Mr. Bertram, whose fee for a single appearance sometimes exceeded £20, there are many intermediate stages of skill.

Dance Music. The fee paid to an agent for a lady pianist for four hours is usually 9s. 6d., with 2s. per hour afterwards and travelling expenses. In other words, she may get a fee of 7s. 6d. plus 1s. 6d. extra for every hour, and her rail or 'bus fare. A man pianist, for the same work, is charged by the agent £1 1s. and cab fare. This probably means for him 15s. for the night. A trio, consisting of violin, cornet, and piano, is usually charged £3 3s. for the night. Quadrille bands cost £1 1s. for each performer.

Concert Promotion. Whether the event be a concert, lecture, dance, or other entertainment, the cost of organisation is first governed by the necessary payments for hiring the hall and adjoining rooms. In municipal buildings, the hall-keeper has a graduated list of charges. For a public meeting of ratepayers, the hall is free. Special reductions are made if the entertainment is in aid of a local charity. On the other hand, for a gathering not coming under these headings, full prices are charged. The cost may vary from £1 1s. for the use of a small room during the afternoon, to £10 10s. or more for the large hall arranged for a concert. Proprietary concert halls have their own scale of fees. The highest charges are usually for an all-night ball. This necessitates the hall being cleared beforehand, and the floor specially prepared. Two guineas may cover cost of printing tickets and programmes for a dance. If light refreshments, or a sit-down supper, are included, the catering is estimated at so much per head. When fixing the price of tickets, the cost of the band must also be considered. Refreshments should be provided for the latter. In other entertainments, the fees of the artists constitute the main items to be defrayed.

Concert promoters should remember that all performers should be given their fees before they leave. The money should be enclosed in an envelope and handed over by the treasurer or secretary, a voucher being signed as receipt. Where several performers receive different fees, enclosing the latter saves unnecessary jealousy. Prompt payment also, after a professional performer has done his best, is more satisfactory than to be told that his "cheque will be sent on."

Lectures. Lectures, either grave or gay, by celebrities well known in the literary world can be arranged through various lecture agencies. The fees paid range from £1 1s. to £10 10s., and expenses. If the lecture is illustrated, and an oil lantern is required, it will cost £1 1s. extra. With limelight, the fee is £1 11s. 6d. A pianist may also be required. Where cinematograph exhibitions are given, the apparatus and attendants will probably run into £5 exclusive of travelling expenses.

OFFICIALS IN SPORTS AND PASTIMES

By Ernest A. Bryant

Cricket and football are essentially the sports of the masses. The development of the attractions of football is one of the most striking features of latter-day outdoor life.

The Professional Footballer. Some thousands of men of varying skill make a livelihood from football, but if a man means to be a professional footballer, he must make up his mind to devote the whole of his time to the game.

Under the rules of the Football Association, the maximum wage to be paid to players is £208 per year. The actual period over which play extends is only thirty-five weeks in each year. Football in public begins on the first day in September, and ends on the last day of April. For seventeen weeks in each year the player has his time to himself, except that in the early days of August he is expected to be within reach of his club to begin training for the first match of the season. Until a few years ago this limit in the wage-earning power of the player did not exist. Men were paid as much as £500 a year in actual wages, to say nothing of the gratuities given for the winning or drawing of matches. It proved in practice that the clubs could not maintain the pace which they had set. Football finance had become one huge gamble. At the end of one season clubs, hoping for success in the following season with the big "gates" which this would mean, bid high for players, and found, too late, that they could not support the liability to which they were committed.

In addition to the £208 per year which a man may receive in wages, he is entitled also to a benefit match after he has served his club for five seasons. This may amount to anything from £100 to £1,000, and so considerably increase the average of his earnings. Only one other payment is permitted: the player on signing an agreement to serve a club is entitled to a gratuity of £10.

The Start. To a man of sound physique, good health, and average agility, the way into a football team of repute is not difficult. Nothing, in fact, is easier, provided he have the qualifications, for football, like cricket, is one of the spheres in which the demand for first-class men always exceeds the supply. A player takes to the game, because he likes it, while a boy. Generally he begins as a forward. If he has not speed enough for that position, or finds that it is more to his taste to spoil the game of another player than to take the initiative in attack himself, then his place is at half-back. Centre half-back is the position at which a man should aim. In that place he must be equally ready with either foot, and this gives him such command of the ball and players that he can take either wing at a moment's notice. He has to accustom himself to placing the ball with accuracy to his forwards, to take a shot at goal himself, or to drop back to the assistance of the men in his rear. He is the pivot of the whole team. The man with a particularly good kick will adapt himself to the full-back position. He must be alert and courageous, and as little prone to nervousness as possible.

From a junior club the player will go to one of better calibre, and soon find, if he has any real aptitude for the game, that openings in still stronger sides are available. Many men have made their entry into First League football while still in their teens, and represented their country in international

matches before their twentieth year has been reached. The trainer of a football team is generally an old player. He looks after the physical training of the men during the week, travels to and from their matches with them, and, in a rough-and-ready way, acts as first-aid in the case of an accident on the field. For a really educated trainer, with a sound knowledge of anatomy, dieting, and rational exercise, there should be a good opening. Many trainers of teams are retired professional pedestrians, whose system of training is wholly wrong when applied to footballers, whose need is speed with endurance. A good trainer can command from £2 to £4 a week. The secretary of the club is generally team-manager. Recently it has become the custom to appoint old players of good reputation to this office, with a clerical assistant to keep the books. The secretaryship of a good club is worth £5 per week. At the end of his playing career—which may extend over ten to fifteen years, the footballer may hope for an appointment as a *linesman*. For this he receives half a guinea a match in addition to travelling expenses. This appointment, if satisfactorily discharged, leads to his engagement as referee, in which he is paid a guinea a match, sometimes two, as well as train fare and hotel expenses.

Cricket. It is less easy to succeed in cricket than in football, for the reason that there are fewer first-class teams. Good men are always wanted, but they cannot produce the necessary ability. There is a vast difference between high-class club cricket and the cricket which even a moderate county side plays. A man who scores hundreds regularly for his local club, or takes half a dozen wickets for next to no runs every Saturday afternoon, may be a hopeless failure on appearing for his county. Men like Hutchings of Kent, and Rhodes of Yorkshire are few and far between. They stepped full-fledged experts into county cricket. With the average man the process is long and arduous. Experience proves that only one man in a hundred can bowl as well as bat. Therefore it is as well, perhaps, that the aspiring player should develop that game for which he has a natural inclination. If he bowls naturally, he had better bowl; if batting be his forte, let him practise batting. But there is this reservation: no man should cultivate one phase of cricket to the entire exclusion of others. The good batsman must learn to bowl sufficiently well to take his turn as a change bowler. Hundreds of matches have been won by the man who goes on to bowl a new style of ball when all the regular bowlers are weary and unable to dislodge a "stone-walling" batsman. Hayward, A. O. Jones, Quaife, the late J. T. Brown, and many other examples will come to mind.

No man should presume to send in his record to his county club until he has made himself a master of fielding. He should model his work in the field upon John Tunnicliffe and Ranjitsinhji, for the slips; upon Jessop, Ernest Jones and Denton for mid-off and mid-on; and upon William Gunn and Victor Trumper for the long field. These men are worth their places in any team for fielding alone; they not only score runs themselves, they prevent their opponents from doing so. And that is the whole aim and art of cricket.

Cricketer's Fees. Thus equipped, the young player at the end of the summer sends in a record to the secretary of his county club, giving his average in batting and bowling for the season. If he be worth a trial, he will either be permitted to play in the following year in one or two of the less important matches, or will be appointed to a place on the ground staff. In the latter case he will bowl for practice games, and members of the club will reward him for skill, assiduity, and courtesy. When he becomes a regular member of the eleven he will receive, on an average, £5 per match, out of which he will have certain expenses to meet. Every time he scores a given number of runs, or takes so many wickets, he will be entitled to what is termed "talent money," while he may be sure that a specially good performance will then and there result in a subscription on the ground. He should average £200 a year from his cricket, while his benefit match will be worth £500 with a team like Warwickshire, or if the man be a Hirst—which does not happen to be likely—he will realise as much as £3,000 from teams like Yorkshire or Lancashire.

Handsome additions to the cricketer's income result from private engagements to "coach" 'varsity or other players, from schools, and from private clubs. When his playing days are done he may be appointed an umpire, for which he will receive a guinea a day. Many men have retaining fees from the M.C.C., to earn which they must play in matches, and make an occasional appearance at Lord's ground.

Gymnastic Instructors. The gymnastic instructor is a man always in demand during the winter. He should be still more in demand. As a rule, however, the instructor is content to follow where others have led. The man who hopes to succeed in this line must be prepared to initiate new schemes for gymnasia. He must, of course, be master of bars and boxing; must be able to show something new with the Indian clubs; invent new exercises with dumb-bells, and have the true eye and supple wrist for single-stick and foils. Army men hitherto have made the best gymnastic instructors, but too often they have preserved the same old system year after year, and killed the interest of their pupils. The man who knows his work will be always devising ways and means, not only of maintaining, but of increasing his membership. A prosperous club can afford to pay him £2 or £3 a week, which sum he will increase by private lessons to nervous or backward pupils.

Billiard Players. The billiard profession is very much envied by young men who can make two or three "twenties" in the course of a game of "a hundred-up." The life is not a pleasant one. Very few succeed. Such harvest as is to result must be gathered early in life, for the vitiated atmosphere in which billiards is played does not make for protracted possession of undimmed eyes and nice touch. The man who succeeds has, as a rule, begun his career in a billiard saloon as a marker. This is the last occupation to be commended. It involves long hours in a bad atmosphere, and temptations to intemperance and gambling. Still, the youth who has an aptitude for the game, and is thoroughly steady, can make a good living in this manner. His salary, which may be anything up to £2 a week, does not matter. His presents prove of more importance. By steady practice he qualifies for match play. He enters the Markers' Handicap, perhaps, or meets privately another player. As soon as his reputation becomes noised abroad he is invited to appear in exhibition matches, and when he qualifies for games in London he may make his thousand or more a year. Once his name is made he can earn a great deal of money by teaching billiards. On the whole, the calling is one of many risks and few successes.

Concluded

THE PUBLIC LIBRARIAN

The Genesis of Free Libraries. The Work of the Librarian. Classification and Cataloguing Systems. How to Become a Librarian

By WILLIAM ANDREWS

THE popular library movement in England goes back only to the middle of the eighteenth century. It was not until 1753 that the British Museum was founded. It was the outcome of a bequest of Sir Hans Sloane, who left his extensive collection of objects of natural history, works of art, books, to the nation subject to the payment of £20,000, two-fifths of its original cost. The Government accepted the offer, and raised the purchase money by means of a lottery. Other collections of books, including those belonging to the English monarchs from Henry VII. to George III., were brought together and formed the library of the British Museum, which is now one of the leading libraries of the world.

The Genesis of Public Libraries. Before the passing of the Public Libraries Acts there were several important free libraries in various parts of the country, the chief being the noble library founded in 1653 by Sir Humphrey Chetham at Manchester. After much opposition, Mr. Ewart got a Bill through Parliament for the establishment of free libraries and museums of art and science, together or separately, in municipal boroughs of England. The Act was a somewhat restricted one, and was extended somewhat in 1855 by another, which remained in force until repealed in 1892 by an Act which provided for the adoption of the Libraries Act by appeal to the ratepayers.

In 1893 an amendment to the Public Libraries Act of the previous year was passed enabling all urban authorities, save the London parishes, to adopt the Libraries Act without an appeal to the ratepayers.

Other Acts have been passed, but they do not affect the main principles, or materially assist the working of the free library movement.

The great usefulness of free libraries is now being fully recognised, and there can be little doubt that in the immediate future their power and usefulness will be extended. In addition to meeting the more popular requirements of a lending library of good and wholesome literature, provision is made for juvenile readers, for getting them early interested in reading, and for helping forward school studies. Reference libraries are formed, containing the best books in various branches of knowledge. In most instances the best and latest technical works are procured, especially those relating to the trades of the place. Collections relating to local history and topography are usually garnered in this part of the library. Provision is made for the student to work with pleasure and profit.

Selection of Books. The formation of a library is by no means an easy matter, and in doing this, where a large number of books is required for a reference library, the librarian usually prepares lists of works covering various branches of learning, and submits them to two specialists in each branch for approval and amendment. Local requirements have much to do with the selection. One point to bear in mind is to have the best books of an author instead of all his works.

Equal care should be taken in selecting the books for the circulating library. Good books which the people will read with pleasure and profit should be placed at their disposal. A library must be kept up-to-date, and to enable the librarian to do this he should read carefully the reviews in the "Athenæum," "Academy," "Spectator," "Saturday Review," "Bookman," the "Times," and other critical journals, as well as watch the advertisements of publishers. The librarian and those under him should know something of the *inside* as well as the *outside* of books, so that when required they may be able to advise those in search of information.

It is customary to invite tenders for the supply of books, and care must be taken that prompt delivery is made. The readers should have new books in their hands as early as possible. All orders should be given in writing, and a copy taken in a copying press. When the books arrive they should be checked with the invoice, carefully collated, not only as regards pages, but also maps and plates. Then those requiring cutting should receive attention. Next the books must be stamped with the library stamp.

Then they are entered in an accession register, and afterwards in the stock-book, which contains a list of all books going into the library. This book should be kept in a fireproof safe. In the event of a fire, it will be required when making a claim on the insurance company. It also shows at a glance the money spent on books. The stock-book should give the following details: Date when the book was admitted, title, author, number of volumes, date published, class, vendor or donor, published price, cost price. Other particulars are sometimes given, such as size, style of binding, etc. It is customary in some libraries to give some of the details indicated above at the back of the title page.

The book is now ready for location on the library shelves. It is entered in a public library in its number in the Cotgreave or other indicator, which is a simple and useful means of recording the issue and return of books. Shelf lists of all books should be kept as a ready means of checking the stock of the library.

Classification. It is not an easy matter to classify books, and some thought and study must be exercised before it can be done in a satisfactory manner. In past times little care has been given to this subject, but to-day librarians are alive to the best methods.

That more generally adopted is the Dewey system, planned by Mr. Melvil Dewey, of the State Library, Albany, New York. By this system knowledge is divided into ten main classes, as follow:

0. General Works.	5. Natural Science.
1. Philosophy.	6. Useful Arts.
2. Religion.	7. Fine Arts.
3. Sociology.	8. Literature.
4. Philology.	9. History.

These classes are subdivided to any extent in tens, as decimals are the simplest means of dealing with figures. The plan of this system has thus been

explained: "5.537 means Class 5, Natural Science; Division 5, Geology; Section 3, Economic Geology; Sub-section 7, Mineral Waters." This seems complicated, but it is really a very simple and elastic system, and is now largely used in both large and small libraries.

Mr. Charles A. Cutter, another American librarian, has a somewhat elaborate system, too elaborate to be extensively employed. It is known as "Cutter's Expansive Classification." He employs the 26 letters of the alphabet to indicate his classes, and the second letter to mark his subdivisions. "This second letter," says Mr. Cutter, "divides each of the 26 main classes into 26 parts, and then a third letter divides each of these 676 divisions into 26 parts, or over 18,000 in all, taking the single letter, the double letter, and the triple letter classes together." Anyone wishing to study this system must consult Mr. Cutter's published tables.

English Classification Systems. A really excellent and simple system was invented by two experienced English librarians, Messrs. J. H. Quinn and J. D. Brown. Books are divided into 11 main classes, as follow:

A. Sciences.	F. History and Geography.
B. Useful Arts	G. Biography.
C. Fine and Recreative Arts.	H. Language and Literature.
D. Social and Political Science.	J. Poetry and the Drama.
E. Philosophy and Religion.	K. Prose Fiction.
L. Miscellaneous.	

"In each main class," says Mr. Brown, "the class letter alone is given to general works covering the whole, or a considerable portion of the subject matter of the class at large. Thus 'B' would mark all the general treatises or dictionaries on the 'Useful Arts,' 'G' general collections of 'Biography.' It has not been thought advisable to make an elaborate system of sub-divisions and sub-divisions, but simply to number in one sequence of even numbers each sub-class or division in its order. This enables the class of most books to be easily expressed by the plain notation of a letter or figure or two—G2, B30, F196, etc. The odd numbers are reserved for fresh divisions of the main classes, and it is thought that this feature will be useful in most libraries where new subjects are continually cropping up." Mr. Brown's "Manual of Classification" must also be studied.

Alphabetical Classification. The London Library is large and well planned. The system adopted is as follows: The books are arranged in broad divisions; that is, History in one division, Theology in another division, and so on. History is divided into one large alphabet. Abyssinia, Arabic, Egypt, England, France, etc., follow each other in alphabetical order. All books in these subdivisions are in alphabetical order under the author's name. This rule applies to all divisions. Theology is one large alphabet of subjects—Bible, Bible Commentaries, etc. Learned societies form one large alphabet, each society being placed under the first word of the title of the society. Periodicals are shelved in a similar manner; fiction under the names of the authors. Biography is one large division under the subject of the biography which brings all the lives of one man together. Miscellaneous subjects, such as Agriculture, Anatomy, Art, Motor-cars, Science, Political Economy, Zoology, are arranged under their respective subjects in alphabetical order in one large division named Science.

It will be gathered from the foregoing systems that a librarian must know something of many subjects to enable him to decide in which class to place a work.

Cataloguing. The compilation of a catalogue is, next to the selection of books, the most important part of the work of a librarian. Before starting one a careful examination of the better examples of catalogues should be studied. The compiler must regard his catalogue as the key to unlock the store of knowledge in his library. It must be simple and concise, but sufficiently full to indicate the nature of the book named. In many libraries used by the more cultured classes, the classified system is employed, and librarians, from experience, know how difficult it is to use by anyone except a well educated person. The dictionary catalogue is now the most popular and the most useful. This catalogue supplies names of authors with lists of their books, the titles of all books, and the subjects under different headings, all arranged in alphabetical order. The contents of some books must be briefly indicated. Numerous cross-references must be given in respect to authors' pen names and real names, and where writers change their names. In short the facts given should enable a person to obtain from a library the book or information required. In addition to printed catalogues, card catalogues should find a place in every library, and be kept up to date. The information on a card may be fuller than in a printed catalogue. Various books deal with this important part of library work, and must be carefully studied, and especially well-compiled catalogues.

Education and Examination. The Library Association, founded in 1877, and incorporated by Royal Charter in 1898, carries out a useful work in teaching and holding examinations, and granting diplomas. Summer schools are held in various parts of the country, and practical lectures are given by experienced librarians. Correspondence classes are also conducted. Particulars may be obtained from the secretary of the Library Association, Whitcomb House, Whitcomb Street, London. The course of training is as follows:

(a) Study in various prescribed subjects, namely: literary history, elements of practical bibliography, classification, cataloguing, library history and organisation, and practical library administration.

(b) Examination in each subject, and the writing of a satisfactory essay upon some aspect of each subject.

(c) Practical experience of not less than twenty-four hours a week, for at least three years, as a member of the administrative staff of one or more libraries approved by the council of the Library Association.

The candidates may study as they think proper, but to gain the full diploma their preparation must include the examinations, the prescribed essays, and practical experience. The "Library Year Book" contains all details of examinations and long lists of books to be studied. According to the regulations, "candidates for the full certificate or diploma of the Library Association shall have passed the examination in each of the six sections, and, if required to do so, a further oral test. Each candidate shall be required to make application not later than March 1st in each year to the Hon. Secretary of the Education Committee of the Library Association asking to be granted the diploma. The application must be accompanied by: (1) A thesis on some topic previously

SCHEDULE OF EXAMINATIONS FOR LIBRARIANS

Age Limit.	Examining Body, Time and Place of Examination.	CERTIFICATE EXAMINATION.	Fees.
None.	Library Association, Whitcomb House, Whitcomb Street, Pall Mall East, London, S.W. In May annually, in various parts of Great Britain and Ireland.	Examination in each subject, and the writing of a satisfactory essay upon some aspect of each of the following subjects: (1) Literary History; (2) Elements of Practical Bibliography; (3) Classification; (4) Cataloguing; (5) Library History and Organisation; (6) Practical Library Administration. Practical experience of at least twenty-four hours a week for three years as a member of Administrative Staff of one or more Libraries approved by the Council of Library Association.	None.
		DIPLOMA EXAMINATION.	
		Each candidate to make application to the Honorary Secretary of Education Committee of the Library Association asking to be granted the Diploma. Application to be accompanied by— (1) A thesis on some topic previously set by the Council. Notice of this topic will be given in the January number of the *Library Association Record.* (2) Certificates showing that the candidate has satisfied the Examiners in each of the sections of the Examination. (3) A Certificate, approved by the Council, showing that the candidate has worked for not less than twenty-four hours a week for at least three years as a member of the Administrative Staff of one or more Libraries. (4) A Certificate, approved by the Council, showing that the candidate possesses an elementary knowledge of Latin, and of one modern foreign language. The Examiners decide if it be necessary to subject the applicant to an oral examination.	

set by the Council. Notice of this topic will be given in the January number of the "Library Association Record." (2) Certificates showing that the candidate has satisfied the examiners in each of the sections of the examination. (3) A certificate, approved by the Council, showing that the candidate has worked for not less than 24 hours a week, for at least three years, as a member of administrative staff of one or more libraries, and (4) a certificate, approved by the Council, showing that the candidate possesses an elementary knowledge of Latin, and of one modern foreign language.

A youth entering a library should master "A Primer of Library Practice for Junior Assistants," by G. L. Roebuck and W. B. Thorne. It not only gives advice of a practical nature, but suggests a good course of reading. All persons engaged in library work should cultivate neat and plain writing. This is a most important matter, for he who writes well among the assistants in a library usually gets the more important work. In addition to the use of the typewriter there is much to be done with a pen. It is to be regretted that more attention is not paid to teaching writing in schools.

How to Obtain a Situation. Situations for youths in libraries are usually advertised in the local newspapers. It is, however, a good plan for a person having a taste for library work to write a letter to the chief librarian in the town in which he resides, asking to be put on the list of applicants for a situation. He must state his qualifications, say where educated, and get a testimonial from his schoolmaster, or clergyman, or minister. Boys in the larger public libraries start at 6s. per week, and at the age of 21 are paid about 25s. per week. If he has made the best of his opportunities he may expect to take charge of a branch library or discharge the more important work in the library, or become a librarian of one of the many smaller public libraries, and work his way into a leading position. Librarianship is by no means a well-paid profession, but it is pleasant and improving. Salaries of chief librarians range from £100 (or even less) to £1,500 per annum. The hours worked are not long, generally about 48 hours per week, but often the assistants are engaged when others are on pleasure bent, and this circumstance often leads to unrest. A man to be a successful librarian, useful to others, and happy in his work, must have a real love of books, and know their contents, and be of use to those seeking information. The ideal librarian should be a many-sided man, know something of everything, and everything about something.

Those engaged in library work often have their tempers tried by people who have no consideration for others, and are lacking in good breeding. It is difficult to deal with such people. We must remember if they are rude we must not sink to their level, but do our best under trying circumstances. The chief librarian should set his staff an example, and they will not be slow to follow his lead.

Bibliography. The following books cover the work connected with a library:

Chambers & Fovargue. "Law Relating to Public Libraries and Museums, and Literary and Scientific Institutions," 1899.

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"British Library Year Book," 1900-1, by Greenwood.

"Guide to the Choice of Books," by Ackland.

"Abridged Decimal Classification," by Dewey.

Library Association series: "Handbook and Library Appliances," by Brown; "Public Library Legislation," by Fovargue and Ogle; "Public Library Staffs," by Cowell; "Public Libraries," by Greenwood; "Care of Books," by Clark.

Concluded

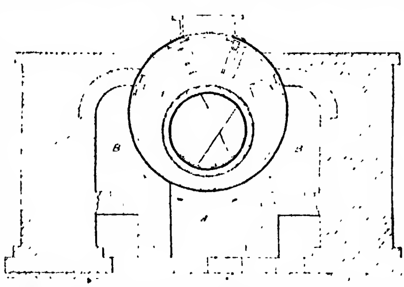
STEAM BOILERS

Classification. Horizontal Boilers. Cornish, Lancashire, Galloway. Multi-tubular, Marine, Locomotive, Vertical, and Water-tube Boilers. Combustion

By JOSEPH G. HORNER

THE function of a steam boiler is the generation of heat, apart from the engine in which the heat is to be utilised. It is a far cry from the earlier boilers, which carried steam pressures of only 3 lb. or 4 lb. above that of the atmosphere to those of the present, in which pressures of 180 lb. and 200 lb. to the inch are common, sometimes exceeded, and pressures of 60 lb. to 80 lb. low. There are certain early types, often illustrated, which are not made now, though their use lingers in some old firms. These are the externally-fired egg-ended boiler, the Rastrick, the box boilers, and the old type of haystack. Also the use of iron for boilers has been nearly discarded for that of steel, with all the practical advantages that result from the use of the latter. The superiority of mild steel over the boiler qualities of wrought iron is the reason why few boilers are made of iron now. Being highly ductile, severe work, such as bending and flanging, can be done upon steel that could not be done upon iron. Its elastic limit being high, it will stand more severe strain than iron without undergoing permanent set. Being of high tensile strength, higher pressures can be carried in steel boilers than in iron with equal scantlings, or equal pressures with lighter scantlings, or with larger diameters. Owing to the absence of lamination in steel plates, they are less liable than iron to deteriorate due to overheating. The methods of constructing boilers have been treated on page 3095. We shall therefore be able to confine the present remarks to the design of the principal types of boilers now made.

Classification. Cylindrical boilers may be classified in two great groups, *horizontal* and *vertical*, signifying that the longitudinal axis of the boiler is either set horizontally or vertically. The horizontal types include the Cornish, or one-flued, and the Lancashire, or two-flued; the modified Lancashire, with three or five flues; the Galloway, with the two flues united into one behind the bridge, therefore a breeches flue type, with a large number of conical tubes. In the horizontal group, all marine—Scotch type—boilers are included, and these also are classified variously. It also includes the multitubular arrangements as used on the locomotive and marine boiler types, which arrangements are also adopted in a good many Cornish and Lancashire boilers. The vertical group includes plain and multitubular forms in many and varied designs. Outside these lies the great group of water-tube boilers. In these, though tubular, the water is contained in nests of tubes around which the fire plays; while in the multitubular boilers proper the flame and hot gases pass through tubes in the water space. The distinction is a vital one, constituting entirely different types.

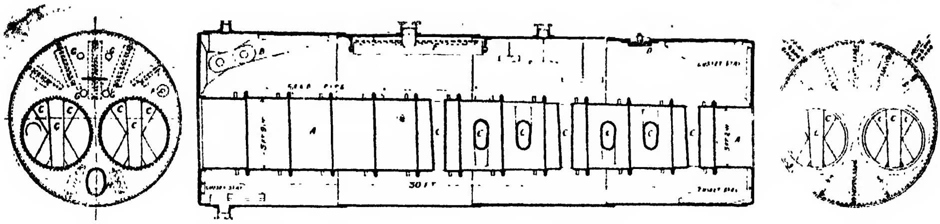


100. CROSS SECTION THROUGH CORNISH BOILER AND SETTING

Horizontal Boilers—The Cornish and Lancashire. The Cornish is a single-flued boiler, shown in cross section in **100**. The flue lies centrally in the horizontal direction, but below the centre in the perpendicular axis, in order to give ample water space above. In Continental types it is placed to one side. A considerable space is occupied by the flue: thus in a boiler 5 ft. in diameter, the flue is 2 ft. 7½ in. in diameter. This is a large space to take away from the water and steam space, and leaves little room between the bottom of the furnace flue and the bottom of the boiler shell, and renders cleaning difficult in the contracted spaces. The Lancashire [**101**] resembles the Cornish in all respects, except that it has two furnace flues instead of one, which is preferable, as boilers increase in size. The minimum diameter of the flues for Lancashire boilers is about 2 ft. 4 in.—2 ft. 9 in. is better—and they range thence to 3 ft. 6 in. The diameter of the flues controls the size of the shell for a given boiler. There should not be less space than 4 in. or 5 in. between the flues, or between the flues and the sides of the shell. Shells range from 6 ft. to 9 ft. in diameter. Lengths vary from about 14 ft. or 15 ft. to 30 ft., 28 ft. or 30 ft. being a usual standard length for a large Lancashire boiler. Roughly, the length of a Cornish or Lancashire boiler is equal to from three and a half to four times the diameter.

The illustration selected [**101**] is one of the standard 30 ft. by 9 ft. boilers by Tinkers, Ltd. It differs from ordinary types in the gradual reduction of the furnace flue, A, toward the back end, and in the hinged character of the gusset stays, B, over the furnace flue. The other gussets are of plated type. The conical tubes, C, are set as in the usual practice, vertically, and at angles of 30° to right and left; D is the manhole; E is the anti-priming pipe whence dry steam is taken. Only the front and back end plates are single-riveted [see the enlarged detail]. The end plates receive additional support from the furnace flues and the gusset stays. Elsewhere the circular seams are double-riveted. The longitudinals eams are treble-riveted through butt straps. Each ring is formed of a single plate, and they break joint in the manner indicated. Such a boiler would, in the old days, have required eighteen iron plates. The furnace flues are plain cylinders, with Adamson flanged seams [see page 3102, and Figure **226**] the seams hit and miss as shown.

The water circulation is sluggish in the bottom of Cornish and Lancashire boilers because the water there lies below the furnace flues. At one



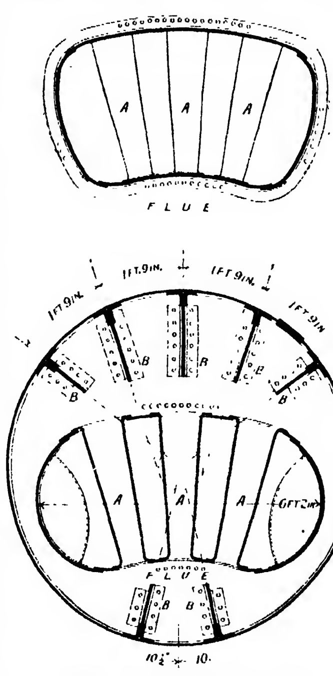
101. LANCASHIRE BOILER, 30 FT. BY 9 FT. (Tinkers, Ltd.)

time this was aggravated by the bad practice of bringing in the cold feed water there, which is now always brought in above them. The seating for the check feed valve which regulates the water supply is seen at F. The seatings for the water gauges are shown at G. H is the mudhole. The various seatings on the top are for different valves. J is for the high steam and low-water safety valve, K is for the junction valve, L for the deadweight safety valve, M is the seating for the blow-off cock.

Galloway Tubes. These, shown at C [101], are so termed from their inventor, and are also called *conical tubes*, from their form. They have added much to the efficiency of both Cornish and Lancashire boilers by improving the circulation between the dead water at the bottom and the hot water at the top. The conical form is imparted simply to permit of the insertion of the smaller end of the tube through the hole cut for the larger end. The tubes are arranged in different planes, vertically and diagonally, in order to allow the hot gases to strike fairly against each successive tube.

The Firegrate and Flues. The firegrate, shown in **103** and **104**, occupies the front of the flue in Cornish and Lancashire and horizontal boilers to a length of 5 ft., 6 ft., or 7 ft. Thence the products of combustion pass through the furnace flue or flues to the rear, and out at the back of the boiler [see the section **100**]. Thence they return through brickwork flues by what is termed a *split draught*; that is, the hot gases pass down the downtake at the rear, and back to the front of the boiler by a central flue of brickwork [**100**, A]. Thence they are diverted to right and left under the action of the chimney draught into side flues, B, B, and so out at the chimney [compare also with **103**]. Frequently an economiser, or feed water heater, is placed in the passage of the gases between the termination of the flues and the entrance to the chimney, so that they yield up heat to the boiler feed water contained in the heater pipes. The gases in their passage through the brickwork flues render up heat to the water in the lower part of the boiler, which is least affected by the heat from the furnace. The brickwork flues are therefore an essential feature of these *land* boilers, as they were formally termed. The boilers are supported on seatings of brickwork, [**100**], which form the walls of the flues. Dampers are provided to regulate the draught. The result is that the boilers are very economical, easy to operate, and have long been deservedly popular among mill and factory proprietors. The fire bridge [**103** and **104**] is a bridge built of brick at the rear end of the firegrate in all boilers of this group. It reaches to within from 9 in. to 12 in. of the top of its furnace flue, and its function is to delay the escape of the hot gases into the smoke flue, and so to promote complete combustion.

Three and Five Flued Boilers. Some of the largest boilers have three fire tubes—two below and one above, centrally. The object is to still further increase the advantage of the substitution of smaller for large flues. Boilers are also made with five flues for burning waste gases.

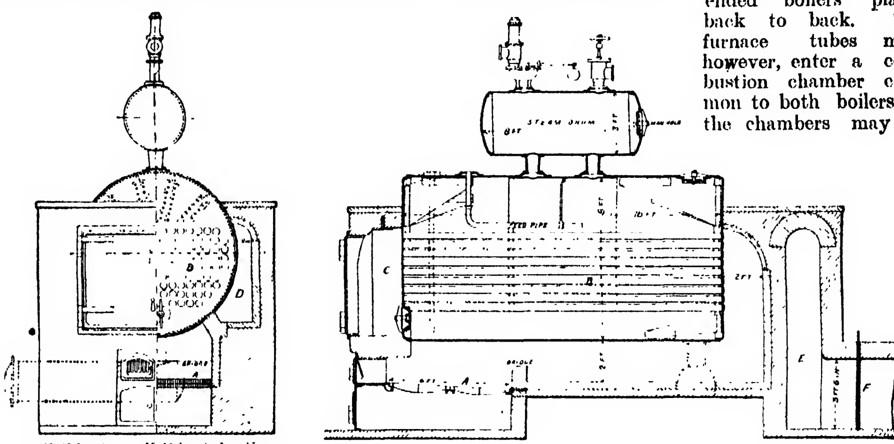


102. GALLOWAY BOILER
A. Conical tubes *B*. Gussets

The Galloway Boiler. This is a modification of the Lancashire type, which gives greater efficiency by increasing the number of conical tubes and providing a number of water pockets. The tubes are not placed as in the ordinary boiler, but in a *breeches* arrangement, in which the two furnace tubes unite in a single smoke flue beyond the bridge [shown in section in **102**], which flue contains the Galloway tubes. A modern full-sized boiler will contain thirty of these tubes, besides four side pockets, which help to break up the flame and heat the water.

Multitubular Boilers. There are considerable numbers of Cornish and Lancashire boilers made of the multitubular design. That is, the furnace flue terminates a little way beyond the bridge, and the hot gases pass through a nest of tubes to the back of the boiler. The tubes are larger than those of locomotives, being generally about from 3 in. to 4 in. in diameter. They vary in number from about 20 to 90. In some designs the tubular system is adopted entirely, as in **103**, which is a horizontal boiler

mounted exactly like a Cornish, over brickwork flues, but is externally fired. It is surmounted with a large steam drum. The flame and products of combustion pass from the grate A along under the boiler, back through the tubes B to the smoke box C at the front end, thence to right and left through the side flues D to the downtake E, and chimney. The damper F regulates the draught.



Half front elevation — Half front elevation, with brickwork removed

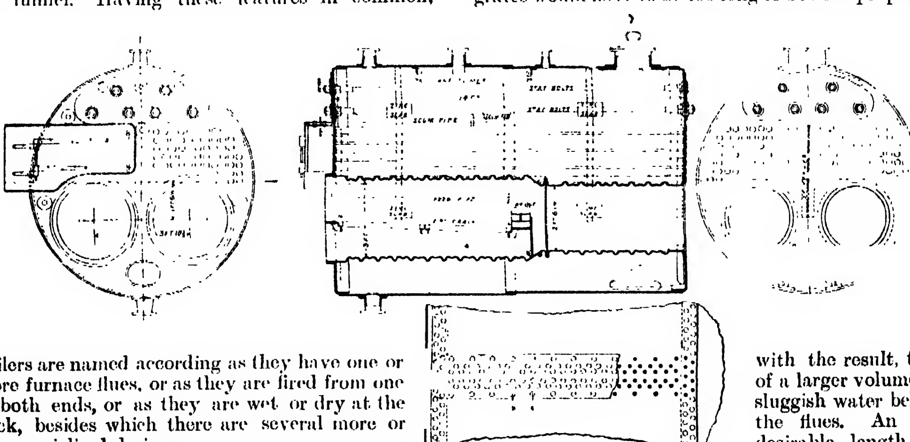
103. MULTITUBULAR BOILER (Tinkers, Ltd.)

Horizontal Boilers—Marine Type. These are commonly termed *Scotch* boilers, and they include several modifications. They are all of *return-tube* design. That is, the products of combustion on leaving the back of the furnace flue return through a nest of tubes which traverse the water space immediately above the furnace [**104**]. At the front of the boiler there is a large casing of sheet iron (not shown) into which the tubes enter. The smoke passes thence into the funnel. Having these features in common, boilers are named according as they have one or more furnace flues, or as they are fired from one or both ends, or as they are wet or dry at the back, besides which there are several more or less specialised designs.

Single-ended Boilers. These are so termed because they are fired from one end only. An example occurs on page 3099 [220 and 221]. The furnace flue C in that figure opens at the end opposite the grate D into the combustion chamber G, which is attached both to the flue and to the shell, and extends up into the latter high enough to cover the ends of the return tubes. Water entirely surrounds the chamber, excepting where it is connected to the furnace ... water covers the chamber and the tubes the depth of several inches, and the space above occupied by steam.

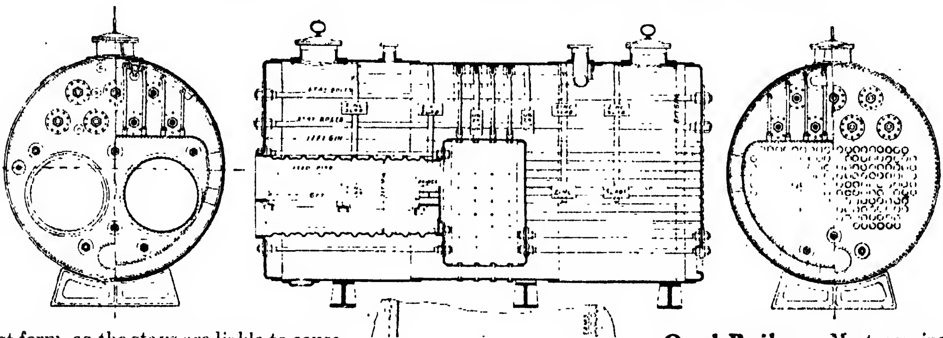
Double-ended Boilers. These are fired from opposite ends, and are essentially two single-ended boilers placed back to back. The furnace tubes may, however, enter a combustion chamber common to both boilers, or the chambers may be distinct, in which case the resemblance to two independent boilers is most pronounced.

Number of Furnaces. Only in the smaller boilers, or those up to about 8 ft. or 9 ft. in diameter, is a single furnace used, the diameter of which should not usually exceed 48 in., and is seldom less than about 36 in. Boilers of 9 ft. and over and up to 13 ft. 6 in. diameter should have two furnaces; up to 15 ft. three furnaces, and over that size, four. If the attempt were made to obtain evaporative power by lessening the number of furnaces and increasing their diameter, the grates would have to be too long to be fired properly, with the result, too, of a larger volume of sluggish water below the flues. An undesirable length of grate would be necessary to get the required grate area, which increases only as the diameter, while the cross section of the flues in which the products of combustion have to be utilised increases as the square of the diameter, which is a correspondingly greater ratio. The question of the number of furnaces involves also that of the combustion



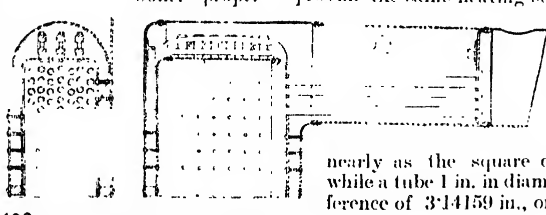
104. DRY-BACK MARINE BOILER (Tinkers, Ltd.)

chambers. The simplest and the worst design is that in which all the furnaces open into one common combustion chamber. The disadvantages are that a leaky tube places the whole boiler *hors de combat*, and that the firing of any furnace produces a rush of cold air all over the surfaces of the chamber. In another design all the furnaces at one end meet in a common combustion chamber and all those at the other end in a similar chamber, the two chambers being divided by a water space. This is not the best form, as the stays are liable to cause trouble. Another design is that in which each furnace has its own independent combustion chamber. It is satisfactory, except on the score of price and weight, and is not, therefore, used so much as the next one named. In this the furnaces, which are opposite to each other, have a common combustion chamber. Each chamber is divided from the one adjacent by water space. To lessen risk of leakage of the tubes, due to the inrush of cold air on the opening of one of the furnaces, a semi-partition, a kind of hanging-bridge of brickwork, is sometimes fitted across the combustion chamber at right angles to the direction of the tubes, and coming some way down into it. This type of boiler is, perhaps, that most commonly used in marine service.



105 TWO-FLUED MULTI TUBULAR BOILER

Dry-back Boilers. The foregoing are all wet-back boilers—that is, the combustion chamber is backed by a water space, and this is the design which is almost invariably adopted. There is, however, a type—the dry-back boiler proper—in which the terminates with the furnace end and tube ends, the combustion chamber being formed with brickwork. Its principal advantage is cheapness. Figure **104** is a dry-back boiler by Tinkers, Ltd., the brickwork not being illustrated. The furnace flue goes right from end to end. There are 114 tubes, 3 in. in diameter, solid drawn. Twenty-four of these are *stay tubes*—that is, they are screwed and nutted at the ends to grip both inside and outside the end plates. There are no gusset stays required at the top, but only those at the bottom.



106. MULTITUBULAR BOILER OF ROAD ROLLER

(Aveling & Porter, Ltd.)

Composite Boiler. In another design of dry-back marine boiler, the combustion chamber is situated at the end of the firegrate just beyond the bridge, and the tubes are carried beyond the chamber instead of returning over the furnace, thus requiring a longer boiler than the usual design. The tubes enter the smoke-box at the farther end. Of the 3 in. tubes in this boiler, 183 in number, 40 are stay tubes. As the roof of the combustion chamber is flat, it is stayed to the top of the shell with *sling stays*, an alternative to the *bridge* or *girder stays* on page 3099 [220 and 221].

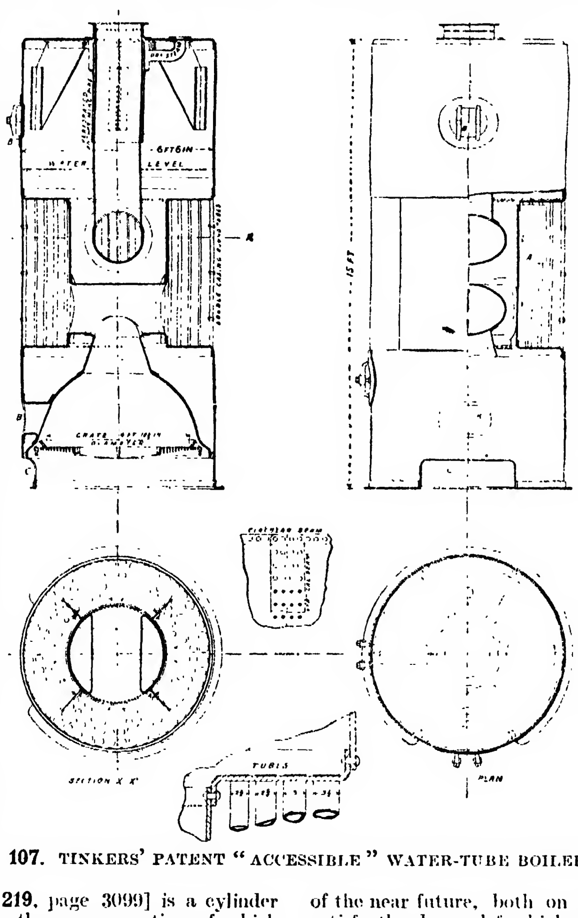
Oval Boilers. Most marine boilers are of cylindrical shape. But a number are made of the so-called oval form, which is, however, composed of two semi-circles connected by flat sides. The only advantage of this is that such boilers can be set in spaces where width is contracted.

The Locomotive Type. In this, the distinguishing feature is the large number of smoke tubes which, passing through the water, assist in the rapid generation of steam. For remarks on these, see the article on Locomotives, page 6514; see also **227**, on page 3101. This type of boiler is used extensively in other ways. It is employed on torpedo boats, differing chiefly in the fact that the firebox is wider, and generally longer. It is used for portable and traction engines, **106**, and for the under-type engines.

In order to obtain a large amount of heating surface from tubes, they are made relatively small, and closely packed. A few large tubes would not provide the same heating surface as a large number of small ones, because while the circumference of a tube increases only as 3·14159 of its diameter, the space occupied increases nearly as the square of its diameter. Thus, while a tube 1 in. in diameter will have a circumference of 3·14159 in., one of 6 in. diameter will have a circumference of $6 \times 3{\cdot}14159 = 18{\cdot}84954$ in. But it will occupy an area of cross section of 28·1744 in. So that in an inch tube, the ratio of circumference to cross section will be 3·14159 to 0·7854, and in a 6-in. tube it will be 18·84954 in. to 28·1744 in. Therefore, by placing a large number of small tubes in a boiler, a much greater heating surface is obtained than by the insertion of a few large ones in the same space. But this must not be carried too far, for then the tubes and spaces are liable to become choked and the circulation impeded.

The Vertical Boilers. The horizontal-flued boilers have a good reputation for staying

capacity. That is, they will maintain a large supply of steam with little fluctuation. The volume of water and steam space is large, the firing can be done very regularly, the water level and the steam pressure can be maintained very easily. On the other hand, they are not suitable for any but permanent service, being necessarily located in one spot over brickwork flues, and being moreover very massive. Hence, for a large extent of service the vertical boiler is employed. It is never made in dimensions so large as those of Lancashire boilers, though the largest vertical are as big as many Cornish boilers. They require no brickwork, and no foundation, and can, therefore, be easily transported and set down anywhere. But they are generally used as a fixed element, as on the foot plate of a steam crane, or a hoisting engine, or a fire engine. Immense numbers are used, more because of their great convenience than for high efficiency. They are not so economical as the Cornish and Lancashire, the steam supply runs down very rapidly under severe service, because the steam and water areas are small, and firing cannot be done so well as in the other boilers named, because the grate is not suitable for preliminary coking of the fuel, being of rather small dimensions, and having no dead plate. Still, for intermittent kinds of service they are useful and popular, and steam can be got up in them in a small fraction of the time required in the boilers laid on brickwork flues.



107. TINKERS' PATENT "ACCESSIBLE" WATER-TUBE BOILER

The vertical boiler [see **218** and **219**, page 3099] is a cylinder standing on its base, the upper portion of which is occupied by steam, and the lower by water, covering and surrounding the internal furnace (firebox). This also is cylindrical, but is a frustum of a cone, the amount of coning on the depth of the firebox amounting to about 3 in. in the diameter. The reason of this is to facilitate the disengagement of the bubbles of steam as they are formed in the narrow annulus between the outer shell and the inner firebox. The two are united by means of a ring at the base—the foundation ring—or by flanging, and also by a ring encircling the firehole. In large boilers a few screwed stays also connect the two. The crown of the firebox is connected to the crown of the shell by means of an uptake, through which the smoke and products of combustion pass into the chimney. In the larger boilers screwed stays also connect both crowns. All boilers of this type, except the smallest, are fitted with cross tubes, ranging from one to three. These are set at angles with each other, and are often inclined slightly from the horizontal to lessen chance of deposit occurring. Mudholes are set opposite the tubes.

Generally the designs of tubular vertical boilers involve firetubes. There are many of these, varied in all conceivable fashions. Many are objectionable, because of the difficulty of cleaning and repairs. A novel design is that in **107**, in which water tubes are fitted, the flame surrounding them being distributed and broken up by the two cross tubes, assisted by the four *diffusion plates* [A] seen in plan and elevation. The circles of tubes increase in size towards the circumference where the heat diminishes. Eight of the outer circle are stay tubes. B is the firing hole, and C the ashpan opening. The drawing is largely self-explanatory.

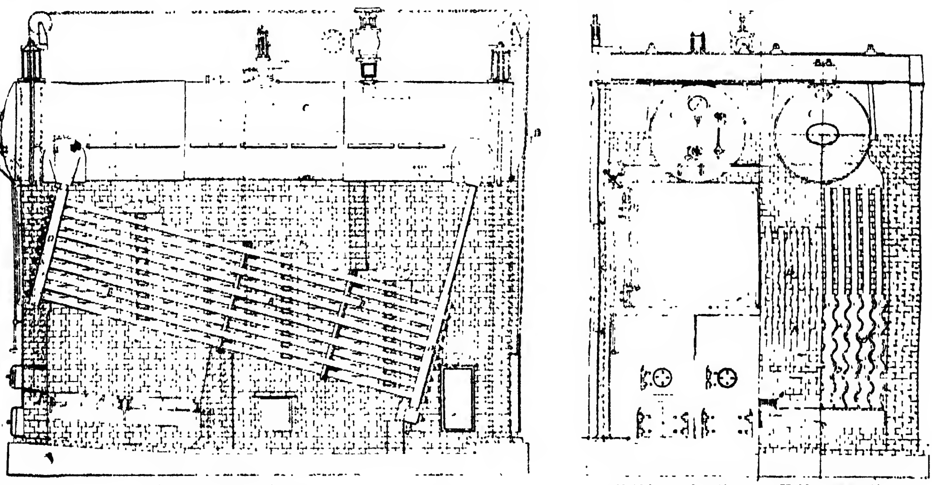
Water-tube Boilers. These have been slowly winning their way to favour as rivals to the Scotch boiler for marine service, and to the Cornish and Lancashire for land power plant. They are used largely in central stations, and are as popular in America as in Europe. They are economical, and the furnaces can easily be designed for burning inferior fuel. Water-tube boilers are the type of the near future, both on land and sea. They satisfy the demand for high pressures with diminution in weight. This is chiefly due to the difference in confining water and steam in the body of a Scotch marine boiler, which is a casing of large diameter, measuring from 14 ft. to 16 ft., and confining it in many tubes of small diameter. The steel plates of which a large marine boiler are made range from $1\frac{1}{4}$ in. to $1\frac{1}{2}$ in. in thickness, and this thickness is necessary to withstand steam pressures of from 150 lb. to 200 lb. to the square inch. But small tubes only $\frac{1}{4}$ in. thick will endure pressures of 300 lb. or 400 lb. to the inch with absolute safety. A boiler, therefore, having water-tubes of 3 in. in diameter, and but $\frac{1}{4}$ in. thick.

is stronger than a cylindrical boiler the shell of which is 1¼ in. thick.

The Belleville boiler is the pioneer broad type on which many others have been designed, the main characteristic of which is the fact that the tubes are inclined within a few degrees of the horizontal. The methods by which they are made to communicate with the steam drum vary in different designs, and their method of fitting also. Some of these differences are of much practical importance; but the only point which we note here is that these boilers constitute a class by themselves, and that their value lies in their capacity for regular service, which renders them suitable for battleships and cruisers, as well as for the mercantile marine, in which they are largely used, and for land service. The boilers of this broad type include the Belleville, the Niclausse, the Babcock and Wilcox, the Dürr, and the Lagrafel d'Allest. The other main type of boiler is that which is used chiefly for torpedo-boats and destroyers. The best known examples are the Yarrow and Thornycroft, the Normand and the Du Temple Guyot. There the tubes are arranged in groups far removed from the horizontal position, being, in fact, sloped several degrees away from the vertical, which imparts to their casings an approximately triangular outline instead of the square, box-like form of the casing of the other types. This broad difference is most important. The nearly vertical slope of the tubes permits the steam to escape more rapidly into the collector or drum than the nearly horizontal arrangement does. Hence these boilers are very rapid steam raisers, and are thus admirably suited for torpedo-boat service. These boilers represent the very highest developments of the water-tube types. They are the nerves and sinews of the torpedo-boat and kindred craft. But the type which is best suited for this service is not the best for a battleship or on land. Not only in naval service, but also in the mercantile marine, these boilers are displacing the older types. Water-tube boilers predominate on the Continent over all other kinds, but they are not as yet great favourites in Great Britain, the exceptions here occurring chiefly in some of the modern works for producing electric light and power.

The Babcock and Wilcox. We can illustrate only one type here [108]. It is one of the few very successful kinds. From five to six millions of horse-power of these boilers are in use in various parts of the world. One of the land type is shown in the figures, encased in brickwork. From the firegrate A the heat passes up among and along the inclined tubes B. C is the drum which contains water and steam. The circulation is set up in the water by the heat, the steam generated in the water-tubes B is liberated, and rises to the upper part of the drum, and water from the lower part of the drum comes down to occupy its place. This circulation goes on through the headers D, D, which are steel boxes into which the ends of the tubes are secured by expanding. The brickwork is enclosed in a casing of sheet steel, and doors are provided to the furnace and to the ends of the tubes. The various valves, gauges, and damper will be noticed.

Combustion. The economical results of combustion are so different under different conditions that it will be well to state what goes on in a boiler. In the most perfect combustion that can occur, the air supplied would be in the exact quantity requisite for the complete combustion of the carbon and hydrogen in the fuel, without leaving any surplus. A portion of the oxygen in the air would combine with the hydrogen liberated from the fuel to form water, gas, or steam, the remaining portion uniting with the gaseous and solid incandescent carbon to form carbonic acid. The steam, the carbonic acid gas, and the inert but heated nitrogen, dissociated from the oxygen of the air, pass on into the chimney, having their heat abstracted from them during their transit. This is a result achieved in few, if, indeed, any furnaces, unless perhaps for exceptionally short periods. The perfect diffusion and intermingling and chemical union of the elements in their combining weights results in intense heat, the heat due to chemical energy; while having no elements left unsatisfied, there is no waste and no thick smoke, the waste gases being nearly colourless. The more nearly practice can be made to approximate to this perfect combustion the better.



Longitudinal section | Half front elevation | Half cross section

108. BABCOCK AND WILCOX BOILER

PRIME MOVERS *concluded*

Group 23
NATURAL PRODUCTS

Following BACTERIOLOGY from page 6784

WORLD'S COMMERCIAL PRODUCTS

The Chief Commercial Natural Products of the World not Described Elsewhere in the "Self-Educator"

A large proportion of the natural products of commercial value have been dealt with in the SELF-EDUCATOR in the places in which they fall naturally, under the particular industry or manufacture in which they are used. But there remain many which must escape treatment on these lines or which are not themselves described as fully as their importance merits. An endeavour has been made to cover these deficiencies in the following pages. The information given in the previous pages will be found by consulting the names of specific articles in the General Index, beginning on page 6900

ABACA—See *Manilla hemp.*

Acacia—The acacia is a genus of thorny trees of which there are several hundreds of varieties. They flourish especially in Africa and Australia. There are several acacias that yield commercial products. The babul tree of India is the *Acacia arabica*, and its wood is a useful timber; its leaves are used as fodder, its bark is of value in tanning and in dyeing, and its gum is used as a substitute for gum arabic. The *Acacia senegal* of West Africa and India yields *Gum senegal* [see *Gums*]. *Acacia catechu* is the source of extract of catechu, which is prepared by boiling the wood chips in water and evaporating the decoction until the extract thickens. The dose of this extract, which is official in India and other colonies, is 5 grammes to 20 grammes; it is given as a tonic astringent in diarrhœa and intestinal hemorrhage. The catechu of the British Pharmacopœia is from another source, the *Uncaria gambier*.

Aconite—Aconite or monkshood [see also pages 352 and 731] is a poisonous plant (*Aconitum napellus*), and the root is now the only portion used, its sole employment being medicinal. It grows in England and in the mountainous regions of Central and Southern Europe. It is collected in autumn, after the leaves and stem have fallen. The roots are trimmed, washed, and dried. The active principle is *aconitine*, which, as an internal remedy (official dose, two grains), is used as a febrifuge and to relieve pain, and as an external remedy for the relief of pain. Aconite poisoning has been successfully treated by hypodermic injections of digitalis.

Alder—The alder (*Alnus glutinosa*) grows in Europe, North Africa, and the North of Asia. A humid soil is favourable to its growth. [For its botanical classification see page 355, and for its physical properties see pages 1260 and 1261.] In appearance the wood is of a reddish-yellow colour, and resembles birch, to which it is akin. It stands immersion in water well, for which reason it is used for pile work, but it decays when wet and dry in frequent succession.

Allspice—*see Pimento.*

Almonds—Almonds are the fruit of the tree *Amygdalus communis*, which grows in the countries bordering the Mediterranean, and in certain parts of Asia. There are two varieties of tree, one yielding sweet almonds and the other yielding bitter almonds. The best almonds are those from Malaga and known as "Jordan" almonds. They have nothing to do with the river of Palestine, and the name may be a corruption of the French word *jardin*, garden. Other varieties imported into this country are known as Valentia, Sicily, and Barbary, all being sweet almonds, used as a dessert fruit and in the manufacture of confectionery. There are also several varieties of bitter almonds—French, Sicily, Barbary, etc.—and from these essential oil is expressed. The bitter almond yields both an essential oil and a fixed or fatty oil; the sweet almond yields only a fixed oil. The best oil is obtained from Majorca almonds. Bitter almonds are generally used, as the cake that is left may be used by perfumers. The residue from the oil-press is steeped in salt water for a day, and the oil is distilled off. The crude oil is suitable for perfumers' use, but if it is to be used for medicinal purposes, the prussic acid contained must be removed. An artificial oil of bitter almonds, otherwise known as *essence of mirbane*, is made from coal tar [see page 4971].

Aloes—Aloes is the dried juice of the leaves of certain trees growing in Africa and in the West Indies. The best variety is Barbados or Curaçao aloes (*Aloe vera* and *Aloe chinensis*), and others are Socotrine or Zanzibar aloes (*Aloe perryi*), and Cape aloes and Natal aloes, the last two of which are not regarded as official by the British Pharmacopœia. The juice is evaporated by boiling to a solid mass or extract, in which condition it reaches our market. Medicinally, aloes is used as a purgative (dose, 2 gr. to 5 gr.), and is reputed to be the chief ingredient in many of the most popular patent medicines. It is prepared as pills, tinctures, mixtures, and other preparations. Its active principle is *aloin* (dose, ¼ gr. as an aperient and 1 gr. as a purgative).

Alum—Alum [see also page 1721, 4780, 5993] is found native as an incrustation upon rocks in volcanic regions, but the greater part of the alum of commerce is obtained from alum shale, a bituminous shale found in this country, in Norway and elsewhere. Rock alum, as the native alum is called, is found in the district around Naples, and in Hungary. It consists chiefly of sulphate of alumina and silica. It is reduced by roasting in kilns, and afterwards by being kept moist for some months, after which the alum is dissolved out and re-crystallised. Alum is used extensively in textile dyeing and printing [see page 5779], in sugar refining, in papermaking, in photography, and for many other industrial purposes. In medicine alum is used as an astringent.

Amber—Amber is a fossil resin, the chief source of which is the Baltic sea, from the bed of which it is detached and washed up. It is used chiefly for the mouthpieces of pipes and cigar-holders, for beads, and, dissolved in alcohol, it is made into varnish. The chips of amber are fused under pressure, making an artificial amber, which is stronger than the natural resin. It is also made artificially from copal, camphor, and turpentine.

Ambergris—Ambergris is a substance of waxy texture and consistency, streaked or veined, and of light grey colour, found floating in the sea. It is supposed to be a biliary secretion of the spermaceti whale. It is found in masses usually of only a few ounces, yet occasionally running up to 2 cwt. It has a pleasant odour and is used extensively in perfumery, not so much, however, for its own perfume, but because it makes other perfumes less fleeting than they would otherwise be. It is readily soluble in oils, and in ether and absolute alcohol. It owes its properties to the aromatic substance *ambreine*. Its market value is about £5 per ounce.

Aniseed—Aniseed is the seed of an annual plant (*Pimpinella anisum*), that grows in France, Spain and the Levant. *Star anise* is the seed of *Illicium anisatum*, a Chinese plant; it resembles European aniseed very closely. The two varieties are equally valuable, being almost indistinguishable in flavour, and both yield an oil by distillation. Aniseed is used as a flavouring ingredient in pastry and in liqueurs, and the oil is used medicinally (dose ½ minim to 3 minims), as a stimulant and carminative.

Annatto—Annatto is a dye in the form of a paste, which settles after macerating with water the pulp and seeds of *Bixa orellana*, a plant that is extensively cultivated in the French colonies in South America. It is used in dyeing [page 5907] and as a colouring for butter and cheese.

Apricot—The apricot (*Prunus armeniaca*) is a species of plum, supposed to have been native to Armenia. It is grown in all parts of Europe except the North, in Syria, Egypt, Eastern Asia, and America. In England the apricot is usually grafted on the plum, but the chief supplies for our market come from France. There are many varieties of apricots, and the *mush-mush* of the Levant is dried and compressed apricots.

Arachis—*see Ground-nut.*

Archil—When subjected to the action of ammonia and air, certain lichens of Ceylon and Portuguese East Africa yield the violet-blue dye known as *archil*. The dye is used for wool and silk. Archil is a liquid dye which, on evaporation, gives *cudbear*, and if further treated with ammonia and lime makes *litmus*, familiar to chemists as the agent for determining acids and alkalis.

Areca—Areca nuts, or betel nuts, are the seeds of *Areca catechu*, an Indian palm which grows also in Ceylon and the Malay Peninsula. The nuts are mottled brown and white in appearance, and are about one inch long. The natives chew the nuts, first cutting them into thin slices, adding lime, and wrapping in betel-pepper leaves. The habit has as strong a hold as has the opium habit upon the Chinese, but apparently has no evil effects. Areca nuts are

used in Western countries as a medicine for dogs and as an ingredient in dentifrice. Cutch, used in dyeing, is made from areca [see page 5906].

Arrowroot—Arrowroot is obtained from the underground stems of a tropical plant, *Maranta arundinacea* [for botanical classification see page 355]. The finest arrowroot comes from Bermuda. The root stems are white in colour, and grow up to 2 ft. long. The starch which they contain is extracted by macerating and washing them, allowing the fibrous outside portion to be removed, and the milky liquid remaining to settle, after which the sediment is taken out and dried. Arrowroot is rich in starch, and is an easily digested food, hence its value for invalids, but it is low in nutritive value. It is extensively adulterated with potato starch. East Indian arrowroot is obtained from different varieties of *Curcuma*, a plant of the ginger family. Florida starch or Florida arrowroot is made from species of *Zamia*.

Ash—There are several scores of varieties of ash-trees. English ash (*Fraxinus excelsior*) provides the most valuable timber [for its physical strength see pages 1260 and 1261; for botanical classification see page 354, and for principal uses see General Index].

Aspen—See *Poplar*.

BAMBOO—The bamboo (*Bambusa arundinacea*) is the name applied to a group of grasses with woody stems that grow in tropical countries, notably India, China, Japan, and to a smaller extent in Africa and America. The common bamboo (*Bambusa vulgaris*) sometimes grows to a height of over 100 ft., with a base diameter of 1 ft. It flowers at intervals of some years, and the grain is used as a food in India. In the West Indies the young shoots are eaten. The hollow canes are solid at the nodes, and this makes them easily cut into vessels. They also serve as pipes and as curtain poles. Cheap tables and other furniture are made from bamboo, and bicycle frames were made from them a few years ago, but this was a fad which speedily expired. There are over 200 different species of bamboo, and several of them are hardy enough to be grown in English gardens. The young shoots of bamboo are used as a paper-making material, the older stems being useless on account of the silicious external coating which they have developed. [See also page 5724.]

Banana—During recent years the banana has advanced in favour in Great Britain until it ranks high among our imported fruits. Our chief source of supply is Jamaica and other West Indian islands. The cultivated banana is seedless, and is propagated by cuttings. The true banana is the *Musa sapientum*, the *plantain* or *pisang* being a subvariety. The Jamaica banana-tree is about 12 ft. in height, and is larger than the Canary or China banana, which grows about 6 ft. high. The plant has root stems which send forth leaves, the petioles of these leaves forming a hollow stem. The blades spread out from the leaf sheaths, and are 6 ft. long or more. The fruit-carrying stems, which spring straight from the roots, emerge from among the leaves. The fruit grows in huge clusters, such as may be seen in our fruit markets—a cluster weighing up to half a hundredweight. The fruit is gathered green, and ripens on its way to our market. The banana is an important article of food in the countries where it grows, but is generally despised by the higher classes. In Jamaica it is given to cattle. The dried flour of ripe bananas is made into bread and cakes, and has some nutritive value, containing about 20 per cent. of sugar and 5 per cent. of albumin, the remainder being nearly all water.

Basswood—See *Lime*.

Baywood—See *Mahogany*.

Bebeeru—See *Greenheart*.

Belladonna—The belladonna, or *Deadly nightshade* (*Atropa belladonna*) is a perennial poisonous plant that grows in Europe, Asia, and America. The root, the stems, and the leaves are used in medicine, being of value for the active principle *atropine*, which is isolated by distillation with alcohol and chloroform. The dose of the leaves is 1 gr. and of the root ½ gr. (official U.S.A.), but in this country the drug is administered only when prepared as an extract or tincture, or as a preparation of atropine, while externally it is used as a liniment, an ointment and a plaster. Externally, belladonna is applied for rheumatism, neuralgia and local inflammations. Internally it is given for spasms, heart failure, fever, acute sore throats, etc., and in the form of atropine is applied to the eye. The antidotes to belladonna poisoning are the stomach-pump and emetics, followed by stimulants, also apomorphine and pilocarpine injected hypodermically.

Benzoin—Benzoin, otherwise called *gum benzoin* or *gum Benjamin*, is a resinous balsam from the *styrax benzoin* of Java and Sumatra. The chief uses of benzoin are in the manufacture of perfumery; as an incense for church use; and in medicine. When lard is used as an ointment base, benzoin is usually added to preserve it sweet. As an external application benzoin is stimulating and antiseptic; compound tincture of benzoin, which is known as *Friar's balsam*, is in esteem as a dressing for wounds. Internally, benzoin is antiseptic, and a stimulating expectorant.

Betel Nut—See *Areca*.

Bibiri—See *Greenheart*.

Birch—The common birch (*Betula alba*) is the most graceful tree of our woods, and is one of the hardest. It can grow in the most exposed situations, and is the only tree found in Greenland. It flourishes throughout Northern Europe and Asia. It grows as high as 80 ft., and has small, serrated leaves, and its fruit is a small nut. The thin outer skin of the bark, which has caused it to be known in some districts as the *silver* birch, was formerly used as a writing material. The bark has been used extensively for canoes by the North American Indians, and in Lapland it is used as a roofing material—two evidences of its enduring qualities. It contains about 10 per cent. of tannin, and is used in leather manufacturing—both in this country and in Russia. Russia leather owes its characteristic properties to birch bark, which, in addition to its tannin, contains an aromatic oil which the leather absorbs. The oil is extracted from the bark and used in leather dressing, and also as an antiseptic for open wounds by Russians. Birch trees are easily propagated from seeds, which are sown in spring in a fine sandy soil, which should just cover them. The wood is soft but durable, with a close and even grain. It is largely used for chair and furniture manufacture, and much turned woodwork is made from it. Selected pieces with fine wavy markings on the surface are used in the form of veneer. There are numerous varieties of birch in Europe and America.

Black currants—See *Currants*.

Bog oak—See *Oak*.

Borax—Borax is biborate of soda and occurs naturally in several parts of the earth, although it is also manufactured from boracic acid obtained by evaporating the waters of the volcanic lagoons of Tuscany, and from borate of lime found in Peru. The oldest source of native borax is Tibet, and it is imported by way of India. It comes from the East under the name of *tincal*, and is frequently received refined, the operation of refining being performed by dissolving it in water and allowing it to recrystallise. The chief source of borax is now the Pacific slope of North America—the Columbus Valley in the State of Nevada, the largest known borax field (10 miles long and 7 miles broad), being a desolate and forbidding region, devoid of vegetation except small saline plants. The most important use of borax is as a flux in glazing pottery and in welding and brazing metals. Boracic acid, the valuable antiseptic and antiputrefactive, is obtained by the action of sulphuric acid on borax. It is used as a powder, as an ointment, a lotion, and in many other forms. Both borax and boracic acid are used to preserve milk and other foods; medical opinion is divided upon the value of this practice, many experts holding that, especially in the case of children, it is pernicious.

Boxwood—Common boxwood (*Buxus sempervirens*) is an evergreen shrub familiar as an edging for garden plots. It is propagated by cuttings, and is developed best by division. It grows slowly. Some varieties of boxwood may reach the height of 20 ft. The wood is hard and close, fine grained, and of even texture. It is most familiar as the material from which carpenter's rules are made, and it is also used for wood engraving and tool handles. Owing to the small supply of true boxwood, a substitute has been found in the West Indies, and is largely used. It is known as West Indian boxwood, or white cedar.

Brazil Nut—The Brazil nut that reaches our market is the fruit of a tree (*Bertholletia excela*) that grows in Brazil, Venezuela, and Guiana. The nuts or seeds—usually from 18 to 24 in number—are contained in a hard shell of round shape and about 6 in. diameter. This outer shell is broken, and the seeds are extracted and dried in the sun before being packed for export. The nuts are rich in oil, of which they can be made to yield 60 per cent. of their weight. The process of oil extraction consists in roasting the nuts and expressing the oil by pounding and pressing. The oil may be recovered also from the unroasted nuts. When fresh, Brazil nut oil, or *Castanha oil* as it is usually termed, may be used for culinary purposes; but as it soon turns rancid its use is chiefly for soap-making and burning.

Broom corn—The broom corn is extensively cultivated for the fruiting stalks, which are cleared of seed and used for carpet brushes or *carpet whisks*, as they are termed, and dandy brushes for stable use [see page 6106]. The plant is the grass *Sorghum dura*, which is allied to the sugar sorghum [see page 4354]. In America, broom corn is an important crop. It is sown as early as

possible in rows about 3½ ft. apart. When the shoots appear, they are hoed and soon afterwards thinned. Then a shallow cutting plough is run between the rows. The corn tops are cut while the corn is yet green, and the seeds are removed by a machine. Then the "brushes," or panicles, are spread on racks to dry and are packed for transport or go into the factory to be made into brushes. The corn stalks after the removal of the crops are 5 ft. to 6 ft. high; they are allowed to remain and are ploughed in the following spring.

Buckwheat—See *Millet*.

CAMEL HAIR—Camel hair is an important article of export from North Africa, Asia Minor, and Central Asia. It is the hair both of the dromedary or single-humped camel and of the two-humped camel proper. It has different degrees of fineness, and different colours according to locality, and to the age and individuality of the animal from which it is taken. One animal yields hair to the extent of about 10 lb. annually, the underside of the neck, the humps, and the upper legs being the places yielding hair sufficiently long to be commercially valuable. The hair from the younger animals is the finer. The Arabs weave it into cloth, making shawls, carpets, etc., with it. Some very fine cloths, which are both warm and soft, are made with it, and the modern prophet who followed the example of his ancient prototype in affecting "garments of camel's hair" would not necessarily lead a life of bodily discomfort. The so-called camel-hair brushes are made with the hair of squirrels' tails, and not with the hair of the camel.

Camphor — Camphor may be regarded as a resin as it is soluble in alcohol to the extent of 1 in 1¼, while it is soluble in water only to the extent of 1 in 700. It is a white crystalline substance obtained from the *Cinnamomum camphora* of Formosa and Japan. It reaches this country in the form of cubes of various sizes and of bells. Flowers of camphor is the powdered form. Camphor is used in wardrobes and museums to prevent the ravages of moths; as an ingredient in varnishes; in the manufacture of fireworks; and in medicine. For external application camphor is of value in sprains, rheumatism, and inflammation, and internally (dose 2 to 5 grammes) it is sedative, carminative, and antiseptic; and is given for nasal catarrh. It is also used extensively in the manufacture of celluloid or xylonite [see page 5470].

Carrageen—See *Irish Moss*.

Catechu—See *Areca* and *Acacia*.

Catgut — Catgut may be included among the natural products. It is made from intestines, but never from those of the cat, hence the name is entirely inappropriate. The intestines used are generally those of the sheep, and sometimes those of the horse, mule, and ass. The first process in manufacture is to clean the intestines thoroughly, after which the small ends are tied together and laid over the edge of the vat or tub, in which the greater portion of the intestine remains to soak for a few days, the water being frequently renewed. This treatment loosens the membranes. Now the intestines are laid on a sloping table and scraped with a steel instrument, which removes the external membrane, which is used for making the strings of tennis rackets and other purposes. The intestines from which the outer membrane has been removed are then steeped for one day and again scraped. The large ends are now cut away and sold for sausage skins. The small parts are again allowed to lie in water, and are then steeped in a bath of water in which potash and carbonate of potash have been dissolved (1 oz. of each to the gallon of water). Then they are drawn by hand or machine through a perforated thimble, which makes them uniform and smooth. After a final washing they are sorted according to size, and are ready for the market if to be sold unspun. If desired to twist them into cords, the lengths are sewn together, the external membrane removed at the first scraping being used as a thread. The sewn lengths are put in suitable numbers into a sort of rope-spinning machine, where they are twisted. They then go into a lead-lined chamber, where they are exposed to sulphur fumes, and are then dyed, smoothed, heated for a short time to make them firm, twisted into strands, and are ready for the market. The chief use of catgut is for musical instrument strings and for cords for clock-weights. It is also used as a cord for sash-weights in sliding window frames. The *silkworm gut* used for anglers' hooks is made by taking the silk glands from the body of the silkworm before it has begun to spin, by extracting therefrom the silk which is still glutinous, and by drawing it out into a thread.

Cedar—The cedars of Lebanon (*Cedrus libani*) are famous historically, and furnished the wood for the Temple of Solomon, but they have ceased to furnish timber for industrial use. The word cedar is now applied to the timbers of different trees which all have the qualities of yielding wood of even grain, light and soft and sometimes aromatic. Cedar used for lead pencils is chiefly the wood of *Juniperis bermudiana*, a red-coloured fragrant wood with the required properties. Red cedars of India and the West Indies are extensively used for cigar boxes. The Indian cedar, or *deodar* (*Cedrus deodara*), is looked upon as sacred, and is found around Indian temples. It is also used for sacred images, for coffins, and for railway sleepers. It is the chief tree of the Himalayas, and grows in forests. The different varieties of cedars are used for furniture—being valuable for the interiors of wardrobes, etc., on account of their immunity from attack by insects—and for wainscotting and turning. The consumption is so great that the market is always on the look-out for new sources or for woods with equally suitable properties. The cedar is one of the most imposing trees in an English landscape, its dense branches of dark leaves making it distinctive. Californian redwood (*Sequoia sempervirens*) is a red cedar, and its timber is the softest used in commerce. The mammoth tree of California (*Sequoia gigantea*) is another variety. It is found only in California, and specimens have been known over 400 ft. high and 110 ft. in circumference. One tree has had a tunnel made through its base, and a roadway goes through it. The *White Cedar* of the West Indies is used as a substitute for boxwood [see *Boxwood*].

Century plant—See *Sisal*.

Charcoal — Charcoal may be wood charcoal or animal charcoal, made by burning wood and bones respectively. In making charcoal intended for fuel, the usual practice is to pile the wood into heaps, usually in a dome-shaped kiln, and burn it until it is charred, the charred wood, which retains its original shape, being the charcoal. For the manufacture of charcoal for gunpowder special care is exercised in selecting the wood, which must be sound and free from adhering bark, and the heat is applied to the outside of cast-iron retorts in which the wood has been placed. Animal charcoal or *bone-black*, as it is also called, is made by heating bones in a retort or crucible, when gases are given off, some of which condense as a heavy oil, called *bone oil*. The chief uses of wood charcoal are as fuel in the manufacture of gunpowder, and as a non-conducting material for cold storage chambers. The chief use of bone charcoal is for decolorising syrups and in sugar manufacture. [See also page 4151.]

Cherry—The cherry is a small fruit of the plum family. There are many varieties of cultivated cherries, which have probably all evolved from *Prunus avium* and *Prunus cerasus*. Cherries are grown extensively in this country, although we derive some supplies from continental Europe and from Canada. Cherry trees should be planted in an open situation with a southern aspect. Standard cherry trees should be planted 24 ft. apart and bush cherry trees 6 ft. apart. Branches should be thinned in July and December every year. The late morello cherry, one of the best cooking varieties, grows best on a wall. Cherry brandy and various liqueurs, including maraschino, kirschwasser, and ratafia, are made with cherries. To make cherry brandy, fill a bottle half full of morello cherries —having cut off the stalks, wiped the fruit and pricked it with a needle. To each pound of cherries add twelve scraped bitter almonds and 3 oz. of sugar candy; then fill the bottle with brandy and allow the whole to stand for not less than six months, after which the liquor may be strained off. There are numerous varieties of cherries, the chief of which are the late morello and the Kentish (both good cooking cherries), the early yellow Elton, the May Queen, the Archduke, and the Black Eagle.

Chestnut—The chestnut (*Castanea vulgaris*) is found in Europe, Asia Minor, and in temperate America. It is also known as the *Spanish* or *sweet chestnut*. The chestnut tree is hardy, but the fruit comes to ripeness only if the situation is sheltered. The tree must have not less than 20 ft. of space all round. The wood resembles oak in colour, being of various shades of brown, and is used for similar purposes. The roof of Westminster Hall is alleged to be chestnut. The wood of old trees is somewhat brittle, and when strength is wanted, younger trees are selected. The nut of the chestnut tree is edible, and is usually roasted. When the nuts are ripe and fall, they should be gathered, taken from their husks and dried. The dried nuts are sometimes ground into flour, and made into bread or fritters. The Italians favour chestnuts as a food, and have several methods of cooking them. They make a porridge of chestnut flour, and call it *polenta*. They also sprinkle rose-water and grated cheese upon chestnut flour fritters, afterwards frying them in fresh butter. The chestnut is not particularly nutritious as a food, but roasting makes it much more easily digested. The nut of the horse chestnut (*Æsculus hippocastanum*) is too bitter for human food, but is sometimes given to cattle. It also contains an oil of a dark green colour, which is expressed,

and in Continental countries is regarded as a specific for rheumatism and gout.

China Grass—See *Ramie*.

Citron—See *Lemon*.

Clingstone—See *Peach*.

Coca Leaves—Coca leaves, the source of the valuable local anæsthetic *cocaine*, are the leaves of *Erythroxylum coca*, a shrub that grows in Bolivia, Peru, and in some parts of Southern Asia. The Bolivian leaves are brownish green in colour, oval, and vary in size from 1½ in. to 3 in. long, by from 1 in. to 1½ in. broad, with a characteristic odour and a bitter taste. Peruvian coca leaves are smaller and more fragile. Coca has remarkable sustaining properties upon both the mental and physical organs, and the South American natives chew the leaves, mixed with lime and the ash of a local plant. The drug is insidious and intoxicating, and many men become slaves to the habit, which shortens life. The official dose of cocaine leaves is ½ dr. to 2 dr. Of the various preparations of coca, the principal is coca wine, given as a nervine and muscular tonic. Of the alkaloids contained in coca, cocaine is the chief. It is used in dentistry as a local anæsthetic, being injected hypodermically into the gum; also externally for burns, insect bites, fevers, etc; and internally as a stomachic. The preparations from cocaine and its salts are very numerous. Antidotes to cocaine poisoning are amyl nitrite, nitroglycerin, digitalis, strychnine, ammonia, and strong coffee, and ether in hypodermic injections.

Cochineal—Cochineal is the name of a dye and of the insect from which that dye is made. This insect is the *Coccus cacti*, the chief sources of which are Guatemala and the Canary Islands. It lives upon several species of cactus, the principal being *Cactus nopal*. The insects are carefully reared, and the females are placed in gauze bags, which are hung around upon the leaves of the growing tree, the buds of which are removed as they appear, so as to give all the sustenance to the leaf growth. As the young insects are born they spread themselves over the leaves. When the time of spawning approaches they are collected into baskets, spread out on the ground or on trays for some time, then placed in heated ovens for a few hours, and finally thoroughly dried in the sun. Black cochineal and silver cochineal are the names given when differently prepared for the market. Cochineal is frequently impoverished or adulterated. Its chief use is in dyeing, although the coal-tar dyes have seriously impaired its value.

Cocoa—Cocoa, or cacao, is the pod fruit of an evergreen plant, *Theobroma cacao*, which grows in the West Indies, tropical America, Guinea, Ceylon, and elsewhere. [The manufacture of cocoa and chocolate has been described on page 6555.] The cultivation of cocoa demands care. The seeds are taken from the ripe pods, and are sown about 1 ft. apart in furrows 2 in. deep, and just covered with earth, on the top of which plantain leaves are spread. After two weeks, shoots will have appeared, and must be kept well watered until they are 14 in. or 16 in. high. Then they are transplanted to sheltered situations, where the soil is well irrigated. The cocoa-tree requires shade, and this is got by planting with them coral-bean trees, which grow much higher than the cocoa-tree. The trees must be pruned regularly, so as to develop a single stem with a full head. There are two harvests a year, in June and December; but in the tropics the fruit gets ripe throughout the year, and what is ripe is gathered fortnightly. The pods are detached with a knife on the end of a pole. The average yield is 6 lb. per tree per annum. Before being exported the pods are cured [see page 6555].

Coconut—The coconut, generally miscalled *cocoanut*, is the fruit of *Cocos nucifera*, a tropical palm, and must not be confounded with the evergreen *Theobroma cacao*, whose pod fruit is made into cocoa and chocolate [see above]. The coconut palm is found in nearly all tropical countries, and there is no single tree, except perhaps the bamboo, which is so generally useful. In the Pacific Islands, in the East and West Indies, and in tropical East and West Africa, the tree grows abundantly. The trees are propagated from the nut, and are planted during the first four months of the year, or in August. The situation should have sun exposure, and the patch of ground should be elevated, so that it may be drained naturally. The nuts are planted about 1 ft. apart in trenches, which are kept moist, but not wet. The shoots are transplanted from two to twelve months after their appearance. About the seventh year the tree begins to bear fruit, and attains maturity about the tenth year, and continues to yield fruit until the seventieth or eightieth year. The annual yield of a tree is from fifty to a hundred nuts. The kernel of the nut contains about 70 per cent. of fat, which, in the form of coconut oil, is largely used in soap manufacture [see page 4832] and for candles. In the West Indies, coolies eat the oil, using it as we use butter. The coconut palm can be diverted from bearing fruit by cutting off the flower stalks; then, by making an incision in the stump and beating it, the juice, which is called *toddy*, is made to flow. This is an esteemed beverage, but ferments quickly, and becomes very intoxicating after standing a few hours. It serves as yeast, and is extensively used by bakers in Ceylon and elsewhere. A sugar known as *jaggery*, and resembling maple sugar, is made from toddy, the unfermented juice being boiled to a syrupy consistency and poured into buckets, where it crystallises. This jaggery is a valuable article of food in some districts; and it has also a limited use in the manufacture of a cement, being mixed with white of eggs and the lime from burnt shells. This cement is highly tenacious, and, when polished, resembles white marble. The fibre that encloses the coconut comes into our market as *coir*. The fibre covering is removed from the nut before the latter is fully ripe, as, if allowed to remain, it becomes more coarse. It is then soaked, preferably in salt water, from six to eighteen months, or for a shorter time if tanks wherein the water is heated by steam be used. The husks are then beaten or crushed in a mill, and finally "willowed," when the fibre is ready for export. The chief use of the fibre is for press bags, used in oil refining, and candle making, for mats and matting, for cheap scrubbing brushes, for a coarse cordage chiefly used in the harvest field, and as a stuffing for cheap furniture. The bark of the coconut palm yields a strongly cohesive gum.

Cod-liver Oil—Cod-liver oil is extracted from the liver of the common cod (*Gadus morrhua*). The chief sources of cod-liver oil are Norway and Newfoundland, the former drawing its supplies of fish from the North Sea, and the latter from the Newfoundland banks. Great improvements have been made in the methods of extracting the oil, with good results regarding the purity and quality of the product. The livers must be fresh, not more than twelve hours after the fish is caught. Good, healthy livers only are selected, others being rejected. They are placed in tubs or open barrels, and as the oil exudes it is ladled off. The livers are then subjected to heat not exceeding 180° F., and more oil exudes. The oil is then subjected to extreme cold in chambers furnished with cylinders or pillars containing brine and snow. The portion that remains after reducing the temperature is drawn off, strained, and filtered, and constitutes the finest medicinal cod-liver oil. After the livers have been subjected to the natural expression described above they are heated again, which causes a further expression, the result being a darker coloured and slightly inferior oil, which is still, however, used medicinally. After this treatment the livers are boiled down, and yield the dark brown cod-liver oil used by tanners and for fattening cattle. The refuse livers are used as manure, and are added to other refuse matter in the manufacture of what is called *fish guano*. Other fish besides the cod—the ling, the turbot, the haddock, etc.—yield oil, which is sold as cod-liver oil, but no oil other than that from cod livers is regarded officially as cod-liver oil. Cod-liver oil has nutritive properties, and is also an active alterative; it is extremely valuable in cases of phthisis. Some stomachs reject it or accept it with difficulty, hence it is frequently given as an emulsion made by mixing with yolk of eggs, water, and other ingredients.

Cola Nuts—See *Kola Nuts*.

Colocynth—Colocynth, or bitter apple (*Colocynthidis pulpa* of the British Pharmacopœia), is the dried pulp of the fruit of *Citrullus colocynthis*, a creeping plant of the cucumber family that grows in Asia, North Africa, and some parts of Europe. When fresh, the fruit is green, but is yellow-brown when dried. Turkey colocynth is considered better than Spanish colocynth, although its superiority has not been established. The official dose is 2 gr. to 8 gr. It is a frequent ingredient in aperient pills, and is a drastic cathartic. The active principle of colocynth is *colocynthin*, a glucoside in the form of an amorphous yellow powder (dose, fifteen minims of a 1 per cent. solution in glycerin).

Copal—Copal resins, much used in the manufacture of superior varnishes for outdoor use, include East African copals, American copals and Kauri, Cowrie or New Zealand copals [see page 1034].

Coral—Coral is formed by some of the marine animals known as *Cœlentera* (meaning hollow-bodied), which have the power of absorbing lime from sea-water, and of building up therewith limy skeletons. These limy skeletons in the mass form what we know as coral, of which there are numerous varieties. The delicate pink coloured coral is the most esteemed variety, and is the dearest. Then there are red, black, and dull-white corals, all of them divided again into several varieties, usually according to colour. The chief sources of commercial coral are along the coasts of Italy, in Dalmatia, and in Algeria. The sole use of coral is for purposes of

ornament, particularly for manufacture into beads, which is an important Italian industry.

Cotton Wood—See *Poplar.*

Cudbear—See *Archil.*

Currants—The dried currants of the grocery shops are small seedless grapes, grown in Greece and the Levant; they are dried and trodden into casks. The name *currant* is a corruption of Corinth, from the district around which they have always come. The currant grape is also grown in Italy, and made into certain kinds of Italian wine. The currant of Greece must not be confused with the berries grown in English gardens, of which there are three varieties—the red currant (*Ribes rubrum*), the white currant (*Ribes album*), and the black currant (*Ribes nigrum*). Black currants make the most profitable market crop. The young shoots are those which carry fruit, and every year all the dead wood and much of the old wood should be cut away. Only as much of the young wood should be cut as will prevent overcrowding of the shoots. In red and white currants slightly different conditions prevail. The young wood should have much more cutting, and the old wood much less, as the latter carries the berries. In May the new shoots should be cut to five leaves, and in the following November to two buds, at which time also the leading shoots should be cut down to six inches long. Bushes without branches in the centre yield the best crop. All three varieties do best in fairly rich soil deeply trenched.

DAMMAR—Dammar is the name applied to a number of resins the chief of which is *Singapore dammar* or *white dammar*, the resin of the Amboyna pine (*Dammara orientalis*), of Java and Malacca. Dammars are used for varnishes and for making sticking plaster.

Damson—The damson is a small, hardy plum largely grown in England, and originally imported from the Levant. The name is a corruption of Damascus plum. It is used for cooking and preserves, and for a pressed conserve called *damson cheese.* The mountain damson, or bitter damson of the West Indies, is the *Simiruba amara.*

EBONY—The name ebony is properly applied only to the heartwood of the trees of the genus *Diospyros*, but it is frequently applied loosely to any hard black wood. The best black ebony comes from India, Ceylon, and the Malay Peninsula (*Diospyros ebenum*). The heartwood is quite black, while the sap wood is white; the latter is removed before the logs are shipped. *Green ebony*, so-called, comes from certain of the West Indian islands, and *red ebony* from Madagascar and Mauritius. Jet black ebony is the species most highly valued. It is used chiefly for inlaid work, and for small turned articles. [For the strength of ebony, see page 1260.]

Elm—There are many varieties of elm; four are found in Great Britain and two are abundant, the common elm (*Ulmus campestris*), and the wych elm (*Ulmus montana*). [For the physical properties and strength of elm see pages 53 and 1260.] Elm is largely used for piles and other work under water. Old water conduits are found to be elm trees hollowed out into cylindrical shape. Elm, however, decays where it is wet and dry frequently in succession. It is also a favourite wood for making coffins. *Spanish elm* is a West Indian wood (*Cordia gerascanthus*), the timber of which is also known as *Prince wood.*

Esparto—Esparto, or alfa (*Stipa tenacissima*), is a grass that is extensively used in paper-making in this country, although it is used for this purpose nowhere else. It grows in Spain, Portugal, Greece, North Africa and elsewhere. It is hardy and can be cultivated in England. The grass grows in tufts and the interior of the leaf sheath is hairy [see page 6280]. The best localities for esparto are on the sea coast facing south and at moderately high altitudes. Chalky soil is best and clay is unsuitable. It is twelve years after sowing before the plant becomes profitable. The most profitable propagation is by burning down the annual flower stems, and a good crop is got five or six years later; but this method is possible only on old esparto land. One acre may give ten tons of the grass. Harvesting can be done only in dry weather, when an experienced man can pull the leaves from the stems, leaving the latter uninjured to develop fresh leaves again. In addition to paper-making, esparto is used for cordage, sieves and baskets, and in upholstery.

FLAX—The uses of flax (*Linum usitatissimum*) have been discussed elsewhere [see General Index]. The seed of the plant—*linseed*—is chiefly used for the oil it contains, which is expressed from it, and which is used as a vehicle for paint, as a cattle medicine and in linoleum manufacture. The residue from the oil-press is made into cake and is a valuable cattle food. Crushed linseed—the *linum contusum* of the British Pharmacopœia—is used medicinally chiefly for poultices, and flax seed is also sometimes given internally for habitual constipation, a teaspoonful floating in water being taken before breakfast. Carron oil, used as liniment for burns, is a mixture of linseed oil and lime water in equal parts.

Freestone—See *Peach.*

GAMBOGE—Gamboge is a gum resin from a tree (*Garcinia morella*) that grows on the coasts of Ceylon, Cochin China, and elsewhere in Asia. The bark is incised as soon as the flowers appear and the resin exudes. It is imported in the form of solid and hollow cylinders, and in cakes; the most esteemed variety being Siamese gamboge in the form of pipes. The chief purpose of gamboge is as a pigment, but it is also used medicinally as a purgative. It is an official preparation in India and the Eastern Colonies.

Gooseberry—The gooseberry (*Ribes grossularia*) grows wild in temperate Europe and in Western Asia, and has of recent years been introduced and successfully cultivated in the United States. It is a hardy plant and grows better in the north of Britain than in the south. The soil should be fairly heavy, deeply dug, and well manured. Full grown bushes should be 5 ft. or 6 ft. apart. The plants are usually reared from shoots, which ought to be cut in September and should be not less than 12 in. long. Cut off the tops of the shoots and plant with about 4 in. showing above ground. Pruning should be attended to, old wood cut away as new shoots appear, and cross branches removed with the knife. The pruning should be sufficient to allow sunlight into the middle of the bush and to permit entry of the hand for picking. Young bushes will yield a crop of about three tons to the acre and after three years quite six tons.

Grape Fruit—See *Shaddock.*

Graphite—Graphite is frequently miscalled plumbago or blacklead, an error which has arisen from the supposition that lead was one of its constituents. It is a native form of carbon, and is found in the form of masses or sheets with mica schist, granite, and other minerals. Its geographical distribution is very wide, and it occurs generally throughout the globe. The only known deposit for many years was at Keswick, in Cumberland, and the mines there were worked to enormous profit for a long time. The chief sources at present are Siberia and Ceylon, the principal known deposit in the former country being in the hands of Faber, the famous German pencil-maker. Apart from the manufacture of lead pencils, graphite finds its most important use as a material for crucibles, and is also used as a dry lubricant, and as a stove polish. It is used also in electrotyping and as a conductor in electrical work. It is manufactured artificially by heating coke in the electric furnace.

Greenheart — Greenheart (*Nectandra rodiæi*) is a tree of British Guiana. It is highly esteemed for its strength, elasticity and enduring properties [see pages 57, 1260 and 6497]. From the bark, which is known as *bibiri* or *bebeeru* is prepared *buxine* or *pelosine*, a sulphate of beberine, used in medicine as a tonic and febrifuge (dose 1 grain to 10 grains).

Ground Nut—The ground nut, also known as the pea-nut, or monkey nut, is the nut of a low creeping plant, *Arachis hypogœa*, which is extensively cultivated in India and the Malay Peninsula, Africa, and America. The nuts are nutritious, and are much eaten in America, being usually roasted. The most economical method of extracting the oil is to clean the nuts, remove the shells, and winnow the kernels free from shells and dirt. The oil is then pressed out cold, after which the residue is finely ground and put under great pressure under steam heat, yielding an oil of an inferior quality. Sometimes there are three expressions yielding respectively a culinary oil, an illuminating and wool-dressing oil, and finally a coarse oil suitable for soap-making. Nut oil is often substituted for olive oil.

Guaiacum—See *Lignum Vitæ.*

Guano—Guano is the excretion of sea fowls, such as sea gulls, penguins, cormorants, and its value as a manure is due to the fact that it contains the most valuable constituents of plant food in a form that can be readily assimilated by the plants. The precise composition of guano depends upon the locality from which it has come, upon the animals or birds responsible for its production, and upon the food of these birds or animals. The chief constituents are nitrogen and phosphates. Nitrogenous guano comes from hot, dry countries, and phosphatic guano from damp countries; the former variety is the more valuable. The best supplies have come from the Chincha and other islands off the Peruvian coast, and less valuable supplies from Patagonia and West Africa. The known supplies of guano are fast becoming exhausted. Artificial guanos are manufactured chiefly from fish and fish offal. Norway has many guano manufactories, making guano from fish.

Guinea Corn—See *Millet*.

Gums—A gum is a substance obtained from plants, and capable of solution in water, so as to form a sticky fluid with more or less adhesive properties. Various so-called gums used in varnish-making and for other purposes are not gums proper, being soluble in alcohol and not in water; they are properly resins [see *Resins*]. The most common gums proper are gum arabic or gum acacia (which constitutes quite a class derived from several sources), gum tragacanth, agar-agar and Iceland moss. Gum arabic is the exudation from the stems and branches of *Acacia senegal* and of other species of acacia. It occurs in the form of round or ovoid tears or irregular masses, and is yellowish in colour or almost colourless. The trees which yield it grow in Egypt and the surrounding districts. The last variety is generally called *gum senegal*. The *mucilage of acacia* of the British Pharmacopœia is made by dissolving 4 oz. of gum acacia in 6 fluid ounces of water. It has a limited use in medicine, not for its medicinal effects, but because it enables other drugs to be held in suspension or in cohesion. Ordinary office gum is made with gum arabic, but is frequently adulterated with or replaced by dextrin. Gum arabic is also used extensively in certain branches of the textile trades. *Gum tragacanth* comes from Asia Minor and Greece. It is the exudation of *Astragalus gummifer*, and has stronger cohesive properties than gum acacia. *Agar-agar* is a seaweed (*Plocaria lichenoides*), found in China and Malaya and is used for jellies, paper varnish, and other purposes. *Iceland moss* is a lichen found in Iceland and North Europe, and is used for similar purposes.

HAZEL—The hazel (*Corylus avellana*) is a common British shrub. It is too small to yield timber of commercial value, but the wood is used for garden furniture, and forked hazel twigs are the common divining rods used by those with the mysterious ability to find water by their means. Hazel nuts are esteemed as a dessert fruit. They yield an oil by expression, and this oil has a limited use in perfumery.

Hemlock—The common hemlock is a native British plant (*Conium maculatum*), of the order *Umbelliferæ*. It is a tall plant having a smooth stem with purple markings, and finely cut, glossy, green leaves. It has a strong objectionable odour and is a poisonous plant. It is used medicinally, usually in the form of a tincture, its action being to paralyse the respiratory centres and the motor nerves. In addition to the hemlock plant which grows in this country, the name is applied to certain North American trees, which are used locally as a building timber. Hemlock bark, so-called, is obtained from one of these trees (*Abies canadensis*), and is a very important tanning material in Canada and the United States. It contains from 7 per cent. to 10 per cent. of tannin and produces a leather of reddish colour. Hemlock extract, containing about 30 per cent. of tannin, is made from the bark and is exported from Canada to the United States and to Europe.

Henbane—Henbane grows in England (*Hyoscyamus niger*) and throughout Northern Europe and Asia. It is a tall herb with large hairy leaves and a pungent odour. Extract of henbane is used in medicine (dose 1 gr. to 2 gr.), and is a hypnotic and narcotic. It contains the poisonous alkaloids *hyoscyamine* and *hyoscine*. The antidotes are the same as for belladonna [see *Belladonna*]. Numerous medicinal preparations are made from henbane.

Henequen—See *Sisal*.

Holly — The common holly (*Ilex aquifolium*) is a well-known hedge tree, growing very close, though slowly. The red berry makes the holly an esteemed decorative tree. From other varieties of holly, which are widely distributed throughout Europe and North America, the holly wood of commerce is obtained. It has a fine close grain, is tough and hard, and is used for cog-wheel teeth, and in cabinet-making.

Horn—Horns are important articles of commerce although many of the manufactures for which horn was formerly the sole material are now made of metal, celluloid and vulcanite or hard rubber. Horns are imported into Great Britain from many countries, the chief being France, Germany, and the Argentine Republic, although none of these supply so much as our own India. The most valuable horns imported and used in manufactures are those of the Brazilian ox, the Cape buffalo, and the Arnee buffalo of India. The most important uses of horn are for combs, for buttons, and for handles for cutlery, umbrellas, and walking-sticks. The horn is prepared for comb manufacture by being softened in water and then in acid; it is then split or sawn into thin pieces, which are subjected to hydraulic pressure. Pieces of horn may be joined together by pressure and heat, and no evidence of the junction will be revealed. Horn may be dyed as desired [see page 6767].

Hyssop—Hyssop (*Hyssopus officinalis*) is cultivated in the South of France. It is a hardy plant, aromatic and bitter. The leaves are used to flavour salads, and are one of the ingredients in the beverage absinthe. The dried flowers are medicinal. An essential oil is obtained by aqueous distillation.

ICE—Ice is a natural product, imported into this country in considerable quantities from Scandinavia. The imports have fallen since ice began to be manufactured artificially. When the ice on the Norwegian lakes is about 12 in. thick it is cut. First an ice plane drawn by horses is passed over it, and then parallel and equidistant grooves are cut with a hand plough, and deepened with an ice plough. A saw is used to remove the first few blocks and the remainder are detached with the help of special breaking bars. The blocks are then floated to the ice-house or to the place of transport, during which they are generally protected by pine shavings.

Indian Hemp—Indian hemp, the *Cannabis indica* of the British Pharmacopœia, is the dried flowering or fruiting tops of *Cannabis sativa*, which grows in Northern India. The herb is an annual, 8ft. to 10 ft. high. The form in which it reaches the western market is a compressed mass, consisting of the stems, leaves, and fruit, matted together with the natural resin of the plant. The official dose of the bark is 5 gr. to 15 gr.; the pharmaceutical preparations made from it are an extract, a fluid extract, a draught, a tincture, and pills. It is narcotic and anodyne, and is given for hysteria, asthma, and migraine. Overdoses are poisonous, although no death from it is on record. The antidotes for it are the stomach pump, emetics, stimulant draughts, artificial respiration, and coffee. Indian hemp induces dreams; is the *hashish* of Alexandre Dumas; and the *bhang* of India.

Indigo—The uses of the dye indigo have been discussed elsewhere [see page 5781]. The cultivation of indigo is an important Indian industry, although the synthetic manufacture of indigo [see page 5463] has inflicted great injury to the cultivation of indigo. Many plants in many tropical and subtropical countries yield indigo; but the most important is *Indigofera tinctoria*. The best soil is rich loam, alluvial for preference. Ploughing takes place in October and November, and sowing in February, March, and April. The harvest is in July, August, and September, when the blossoms are full. The dye is generally prepared by the green leaf process. In this process the plants are cut down and put into tanks, being held down by beams placed on top of them and athwart the vats. They are covered with water and allowed to steep from ten to sixteen hours, the duration depending upon the weather. Men then go into the tanks and agitate the contents for from two to four hours, until the fecula begin to separate and settle and the colour of the water changes from green to blue. More water is added, and this hastens the deposition of the fecula, and after a few hours the water is run off from the top, leaving the deposited fecula, which is then taken and boiled for about six hours under continuous stirring. The contents of the boilers are run off into strainers, and after about twelve hours the remaining mass is pressed, cut, stamped, and dried, the final product being the indigo of commerce. Other sources of indigo, besides India, are China, Japan, Siam, the Philippines, Java, and some South American countries.

Ipecacuanha—The drug known under this name is the root of *Psychotria ipecacuanha*, a shrub growing in South America and the East Indies. Its uses in medicine are as an expectorant and an emetic. It is a favourite remedy for croup and other diseases of children, being given generally as ipecacuanha wine (adult dose 10 drops to 30 drops as an expectorant, and 4 drachms to 6 drachms as an emetic). The dose of the powdered root is ¼ gr. to 2 gr. as an expectorant, and 15 gr. to 30 gr. as an emetic. The drug contains two alkaloids, *emetine* and *cephæline*, and powders and other preparations from which the former is extracted, are given for dysentery. Extracts, tincture, syrup, and pills of ipecacuanha are also made.

Irish Moss—Irish moss, or Carrageen, is a seaweed (*Chondrus crispus*) the commercial sources of which are the west and north-west coasts of Ireland and a small part of the coast of Massachusetts. In America, whence comes the greater quantity, the moss is pulled from May to September, boats being used to reach the rocks. Spring tides are usually chosen for the pulling, as the ebb of the tide leaves more rock surface uncovered then. The moss is bleached in the sun, washed repeatedly in salt water, and dried. Irish moss is used medicinally for jelly for consumptives, and as a decoction flavoured with sugar and lemon juice it is demulcent and nutritive. It is also used for refining beer, and the poorer qualities for making size for cotton and paper. Sometimes it is fed to cattle.

Istle—See *Sisal*.

Ivory—True ivory is the tusk of the Indian and African elephant. When

the elephant is tamed, the tusks decrease in size and deteriorate in quality, hence the tusks of the wild elephant form the best ivory. The African elephant usually possesses larger tusks than the Indian elephant. The former have yielded tusks up to 200 lb. weight, and even heavier, but the latter seldom show more than 70 lb. weight. The use of ivory has diminished for cutlery hafting, billiard balls, etc., since xylonite or celluloid appeared on the market. Tusks that are only slightly curved are preferred to those with sharper curves and twists. *Fossil ivory* or *mammoth ivory* is a true ivory from the ice-preserved remains of the extinct mammoth elephant *Elephas primigenius*, and is found within and near the Arctic circle of the three northern continents—notably in Siberia. The largest variety—supposed to be the tusks of the male—are about 9½ ft. long, and a smaller variety—supposed to be the female—about 5½ ft. long. These are true ivories; there are other so-called ivories that are not true ivories. *Walrus ivory* is the tusks of the walrus or sea horse, and is obtained chiefly in Alaska. These tusks are sometimes as long as 2 ft., and usually weigh about 2 lb. each. They are coarser than elephant and hippopotamus ivory, and commercially are of less value. *Hippopotamus ivory* is the tooth of the African hippopotamus. It is harder than elephant ivory, less liable to stains, and of delicate whiteness, but it is inclined to be brittle. The supply is small. Hippopotamus ivory is used for the handles of surgical instruments and for other purposes for which elephant ivory is employed. *Narwhal ivory*, sometimes wrongly called *swordfish horn*, is the tusk of the male narwhal or *sea unicorn*. It is obtained as long as 10 ft. It is the supposed *unicorn's horn* esteemed in medicine a few centuries ago. The supply is small, the quality coarse, and the value low. *Dugong ivory* is the tusk of the Australian dugong or sea cow. Only the male has tusks, and these have a value as ivory. The supply is small. *Vegetable ivory* is the albumen of a South American nut [see page 812].

JACARANDA WOOD—See *Rosewood*.

Jalap—Jalap is the tuberous roots of *Ipomœa purga*, a Mexican plant, which also grows in Jamaica and India, and even in the South of England. The roots are dug up and dried, the larger ones being sliced open to hasten the drying process. The dose of the powdered root is 5 gr. to 20 gr. Its effect is purely purgative, and it is much less used than it was a generation ago. It is also administered as a tincture, as a compound powder, and as an extract.

Jarrah — Jarrah (*Eucalyptus marginata*) is the best known of the West Australian hard woods, and is extensively used in this country for paving blocks. It is also used for piles and railway sleepers, as it is very durable, and has the property of resisting attack by animal organisms that destroy most other woods. The tree grows to a great size, so that large planks can be obtained. The Karri (*Eucalyptus versicolor*) is closely allied to Jarrah, and is also from Western Australia. It has similar uses.

Jet—Jet is a variety of lignite or brown coal which has turned black by fossilisation, and it was formerly extracted from the Upper Lias shales near Whitby. It occurs also in other countries—notably Languedoc in France, Galicia, and Massachusetts. The harder pieces are the jet, which is cut into beads and other ornaments. These are intensely black, and take a high polish. Jet, as a material for ornaments of personal adornment, used to be much more fashionable than it is to-day.

Job's Tears—See *Millet*.

Juniper—The common juniper is an evergreen shrub (*Juniperus communis*) which is indigenous in Great Britain and North Europe. The fruit of the juniper—juniper berries—is used in the manufacture of gin. Raw grain spirit is flavoured with the ground or crushed berries, or bags containing juniper berries may be suspended in the still, this being held to yield the better product. Holland is the chief seat of gin manufacture, the centre of the industry being Schiedam, where the world-famed schnaps is distilled. British gin—so-called—contains no juniper berries, being merely grain spirit flavoured with turpentine. Oil of juniper is a volatile oil obtained from the berries by distillation, and is of greenish-yellow colour, and of a turpentine taste. It is given medicinally (dose 5 min. to 20 min.) as a diuretic and for kidney troubles. A variety of juniper (*Juniperis oxycedrus*) yields oil of cade, which is used as an external application in diseases of the skin, including eczema. Sandarach [see *Sandarach*] is frequently erroneously called *gum juniper*. The so-called cedar wood used for lead pencils is the wood of *Juniperus bermudiana* [see *Cedar*]. Virginian red cedar is the timber of *Juniperus virginiana*, and is much used for furniture on account of its immunity from attack by insects.

Jute—The treatment of the jute fibre in the textile industries has been considered elsewhere [see General Index], and the remarks in this place will concern only the cultivation of the plant. The two jute plants cultivated for the fibre are *Corchorus capsularis* and *Corchorus olitorius*. The chief seat of the jute cultivation is India, especially Bengal, although China and the Malay Peninsula are also not unimportant sources. The former plant is the larger, although both are of equal industrial value. They are annuals, and are most successfully cultivated in a loamy soil and in a hot damp climate. The sowing season is from the middle of March to May. The flower is yellow. When from 5 ft. to 10 ft. high, and in flower, the plants are cut down, the harvest being from July to October. In cutting, a sickle may be used, or the plants may be uprooted entire. Bundles of stalks are immersed in stagnant water to rot, and remain there from a few days up to a month. This separates the inner bark from the rest of the stem, and the inner bark is that used industrially. The final separation of extraneous matter is effected by manual labour, a man standing in the water and pulling off the bark in long lengths. After washing the fibres, the water is wrung out, the fibres are hung up to dry, and are finally packed in hanks and bales for export or for the factory.

KARRI—See *Jarrah*.

Kauri Pine, or Cowrie Pine—This timber (*Agathis australis*), is the most important exported from New Zealand, and constitutes the greater part of the timber exported from the new Dominion. It is found in the extreme north of the colony, and also in the district around Auckland. It is a tall tree, growing to the height of 160 ft., with a straight, smooth trunk rising 100 ft. before the first branch is reached. Its diameter is from 5 ft. to 15 ft. The grain of the wood is straight; the wood is easily worked, is sound, and free from knots, and can be highly polished. The great length and breadth of the planks obtainable from the tree added to the qualities mentioned, make it a very valuable wood for many purposes. Its length makes it fitted for ship masts, and it is also used for ship decks, flooring, and general house work, vehicles, furniture, and paving blocks. It has also been used for church fittings. [For its strength compared with other woods, see page 1260.] Kauri gum [see page 1034 and 5123] is a valuable resin used for varnishes and in linoleum manufacture. It is found chiefly as a fossil gum in ground where the tree has grown during thousands of years. A small quantity of the gum is obtained from growing trees.

Kola Nuts—Kola or cola nuts are valuable on account of their active principle, the alkaloid *caffeine*, which is also found in coffee. There are two trees that yield kola nuts, the *Cola acuminata* and *Cola vera*, both being native to tropical Africa and the latter being the more valuable. The nuts are chewed and eaten by the natives on account of their sustaining and stimulating properties. The alkaloid caffeine stimulates the heart, raises arterial tension, and keeps off fatigue; it is given as a diuretic, and for kidney troubles and typhoid (dose 1 gr. to 5 gr.). Antidotes to caffeine poisoning are the stomach pump and emetics.

LARCH—The larch (*Larix europœa*) is a valuable timber. [For its cultivation, see page 4679; for its properties and uses, see page 55; and for its strength, see page 1260.] The bark of the larch is used as a tanning material, and is valuable for light leathers. It contains about 11 per cent. of tannin. *Venice turpentine* is the exudation of the larch. Incisions are made through the bark of the tree, usually about the end of March, and the turpentine flows during the summer.

Lavender—Lavender is the flowers of a hardy perennial herb (*Lavandula vera*), cultivated at Mitcham and elsewhere in the South of England, and in Southern Europe. The dried flowers constitute the lavender of commerce. They retain their perfume for a long period, hence their value. Oil of lavender is made from the female flowers by distillation. English oil of lavender commands a much higher price than foreign oils, due to the care with which the plant is cultivated and the oil expressed. The first oil expression is used for the manufacture of lavender water, and the later expression for soap perfumery. The oil from the male lavender (*Lavandula spica*) is known as *oil of spike*, and its chief use is for artists' colours.

Lemon—The lemon is the fruit of *Citrus limonum*, a small tree of the orange family. The tree is about 12 ft. high, and thorny; it carries numerous branches, bearing oval leaves and five-petalled flowers. There are several varieties of lemon, including the citron, or Median lemon (*Citrus medica*), the pearl lemon (*Citrus margarita*), and the sweet lemon (*Citrus lumia*). The juice of the lemon has a distinct medicinal value, due to the citric acid contained. It is valuable in malaria and in scurvy, and has been given with good results in chronic rheumatism. Oil or essence of lemon is expressed or distilled from fresh lemon-peel. [See pages 4968 and 4969.]

Lignum Vitæ—Lignum vitæ is the heartwood of a West Indian tree (*Guaiacum officinale*), and is the heaviest and hardest wood known. The tree grows to a height of about 40 ft., and to a circumference of 4 ft. or 5 ft. Its branches are numerous and knotted. Jamaica is the chief source of the lignum vitæ imported into England. The wood is of a dark green or brown colour, freely streaked, and is so cross-grained that it cannot be split, and must be sawn or turned. Its chief use is for pulley blocks and rollers in machines of various kinds. [For its strength, see page 1260.] The resin of the tree—*guaiacum resin*—is used extensively in medicine (dose, 5 gr. to 15 gr.). It is used for rheumatism, lumbago, and diabetes. It is also administered as a tincture, a mixture, and in the form of tablets and capsules.

Lime—The lime tree (*Lilia europæa*) of North Europe must not be confounded with the fruit-tree described below. Our lime tree, the linden of Germany, is of rapid growth, and flourishes even in the dust-laden atmosphere of cities and towns. The trunk is thick, and the branches are slender, close, and upright. The leaves are large and flat, coming to an apex. The tree attains a great age, frequently over 1,000 years. The flowers are sweet-smelling, and contain honey, which attracts bees. The timber is white and close-grained, and makes a good carving wood. Acetic acid is obtained from it by distillation [see page 5465]. Basswood is the timber of the American lime-tree, and is common in Canada and in the eastern portion of the United States. Its nature and uses are similar to those of our lime tree.

Lime—The lime (*Citrus medica acida*) is a valuable fruit of the orange family that is extensively cultivated in the West Indies, and to a less extent in India and Burma. The common tree is very spiny, although one variety is spineless. It grows in poorer soil and in more exposed situations than the lemon, and the fruit is small—about one-third as large as a lemon. Lime-juice has anti-scorbutic properties, and by English law every ship must carry a supply, a precaution which has banished scurvy from our mercantile and naval marine. The juice is expressed by pressure, and is afterwards filtered and clarified. Sweet limes (*Citrus medica limetta*) grow in Southern India, and are not so highly esteemed as the common or sour variety.

Linseed—See *Flax*.

Liquorice—Liquorice is the root of *Glycerrhiza glabra*, a plant that is widely distributed throughout Southern Europe and Asia. The root enters our market in a dry state, and is sweet, mucilaginous, tough, and flexible. The root is manufactured into extract of liquorice, being crushed, boiled, and evaporated. The condensed juice—black or brown in colour—is rolled and stamped with the maker's name, and in this form comes to our market. The most esteemed brand is *Succus solazi*. The powdered root is the chief gredient in compound liquorice-powder, and several other preparations are used medicinally. Liquorice is a mild and agreeable laxative.

Litmus—See *Archil*.

Locust Beans—Locust beans are the pod fruit of the *Ceratonia siliqua*, or carob tree, common in Southern Europe and the Levant. They are the reputed food of John the Baptist in the wilderness, and are hence known as St. John's Bread. The chief sources of the locust beans imported into this country are Sicily and Southern Italy.

Logwood—Logwood is a tree (*Hæmatoxylon campechianum*) that grows in Central America. The heartwood is cut into chips, moistened and exposed to the air, when it undergoes fermentation and turns a deep red, and is then suitable for use as a dye [see page 5905]. A decoction and an extract of unfermented logwood are given medicinally for diarrhœa.

Loquat—The loquat (*Eriobotrya japonica*) is the Japanese medlar or quince. It grows in England in sheltered situations, but as it flowers in autumn it must be grown under glass if the fruit is to ripen. The fruit is of an orange yellow colour, small, round, or pear-shaped, and clustered. The flowers are white.

MAHOGANY—Mahogany (*Swietania mahagoni*) ranks pre-eminent among high-class timbers, in spite of many rivals to favour. There are two varieties of true mahogany—Spanish and Honduras mahogany [see pages 56 and 1260]. When the tree is cut, the wood is of a light reddish colour, but exposure to light darkens it. Honduras mahogany, known also as *baywood*, is not figured like Spanish mahogany, and is more brittle. The best Spanish mahogany is now used only as a veneer. The largest mahogany logs come from Mexico, but this variety is apt to be soft in the centre, and to develop star shakes. Other varieties of so-called mahogany come from India, and Africa. The mahogany-trees are cut in the height of the dry season—April and May—and after being squared and freed from branches and hauled to the rivers by oxen, are launched, made into rafts, and floated to the sea for shipment.

Maize—Maize is also known as Indian corn, and as mealies. It is the grain of a tall grass, *Zea Mays*. [For its cultivation, distribution, and food value, see the pages indicated in General Index.] Maize starch or cornflour is used as a substitute for arrowroot, and starch for laundry use is made from it by crushing it and allowing the starch to settle in water. Maize straw is used for paper-making. Maize oil is extracted from the grain by hydraulic pressure, and is used as a salad oil and in soap manufacture.

Manilla Hemp—The use and prospects of abaca or Manilla hemp (*Musa textilis*) have been discussed in the course on Textiles [see page 719]. The fruit of the plant is a non-edible banana, and the leaf sheaths furnish the fibre. The plant flourishes best on hillsides, and the atmosphere must be humid. The plant is propagated from root suckers or from seeds, the former taking three years to mature, and the latter about double that time. As the buds appear, the plant is cut down, the leaf sheaths are detached and split into layers and then thinned into strips about 2 in. wide and ¼ in. thick. Scraping removes the pulp, leaving the white strips ready to be baled for export. Owing to its strength, Manilla hemp is of great value as a cordage material.

Manna—Manna, a saccharin exudation from *Fraxinus ornus*, or the manna ash, comes to our market chiefly from Sicily, although it is also obtained in Southern Europe and Asia. It is obtained by incising the tree, when the manna exudes and hardens—at first, brown, but turning harder and whiter. Manna reaches us in the form of flakes, and indeed is known as *flake manna*. As a drug, it has mild laxative properties, but is not an official remedy in this country, although it is official in the United States. Dose, ½ oz. The manna of the Old Testament was probably the honey-dew of a Mediterranean scale insect.

Maple—The maple tree has many species. The common maple of our country (*Acer campestre*) is of no use for its wood. The maples of commerce come from North America, and the maple leaf is the Canadian national emblem. The beautiful deep and variegated hues taken on by the maple leaf in autumn give the Canadian woods a wonderful wealth of colour. The most important species of maple is the sugar maple (*Acer saccharum*), which yields maple sugar [see page 4351], the red maple (*Acer rubrum*), the silver maple (*Acer saccharinum*), and the broad-leaved maple (*Acer macrophyllum*). [For the uses of maple, see page 57, and for its strength, see page 1260.]

Mastic—Mastic is the resinous exudation from a shrub (*Pistacea lentiscus*) growing in the countries bordering the Mediterranean Sea. It is imported in yellowish or greenish tears and is used for varnish manufacture. It is also used, dissolved in alcohol, by dentists, being placed on cotton-wool to apply to the mouth during the application of an antiseptic. There are also an Indian and a Cape mastic of less importance.

Medlar—The medlar (*Mespilus germanica*) was once a more popular fruit than it is to-day. The flowers are large and white, with five-cleft calyxes and corollas, and the fruit is lemon-shaped. The tree grows best in heavy, moist soil, somewhat sheltered. The medlar is generally grafted on seedling medlar stock, or on pear, quince, or whitethorn stock. The fruit should be gathered at the end of October, and kept a few weeks before being eaten. The *loquat* is the Japanese medlar [see *Loquat*].

Meerschaum—Meerschaum is an earthy mineral, white or yellow in colour, and consists of hydrous silicate of magnesia. It occurs in veins or nodules, and the chief commercial source is Asia Minor. Before being exported, meerschaum is scraped to free it from the earth with which it is usually associated, then dried in the sun or in ovens, scraped again, and finally polished with wax. The common qualities are used in the manufacture of porcelain, and the best pieces are made into meerschaum pipes, principally in Vienna and Paris. The absorption by the meerschaum of oil from the tobacco causes the colouring of meerschaum pipes.

Millets—Certain cereal and forage grasses are known as *millets*. The importance of millets as food may be judged by the fact that about one-third of the world's population—chiefly Asiatic—eat it regularly. Sorghum, also known as *Guinea corn*, and in Egypt as *dhurra*, is a variety of millet. It is used in sugar manufacture [see page 3652], and as a cattle food. Young sorghum should not be given to cattle, as it has been proved to be poisonous, but the mature plant is free from poison. Job's tears, the fruit of *Coix lachryma*, which grows in India and Japan, is a variety of millet, and is used for ornamental purposes, chiefly for beads and mats. *Buckwheat*—erroneously named, for it is a small nut, not a wheat—is another millet, and is used as a food chiefly in Russia and in the United States.

Mother-of-Pearl—See *Pearl*.

Mulberry — The mulberry (*Morus nigra* and *Morus alba*) is a small tree

of the stinging-nettle order. The black mulberry yields a black, luscious berry. Planting should be done at the end of October or the beginning of November in well-drained soil. The young branches should be cut, leaving only four, and these should be cut back to 3 in. or 4 in., and to an outer eye.

Muscatel—See *Raisin*.

Mush-Mush—See *Apricot*.

Mushrooms—Mushrooms are a species of edible fungi of our woods. They can be cultivated in any situation with a uniformly warm temperature. Underground cellars make admirable mushroom beds, and in one case, at least, highly successful results are got by utilising a disused railway tunnel for the purpose. The temperature should be kept at about 50° F. The mushroom beds may be made in boxes or shelves, 2 ft. or 3 ft. wide, and ranged above each other against the walls. Dried horse manure, either alone or mixed with 25 per cent. (by measure) of loam, forms the best material for the beds. This is placed on the shelves or in the boxes to the depth of about 1 ft., and is pressed firmly down. The beds of manure will develop heat, and when this is subsiding, and is about 90° F., the spawn should be broken up into pieces about the size of walnuts, and placed in the bed about 6 in. apart. Eight days afterwards, a layer of heavy loam, 1 in. thick, or more, should be put on the surface and beaten down hard. About a month later the mushrooms appear. There are many more edible fungi in our woods besides the mushroom, but fear of the poisonous varieties prevents their use. Mushrooms, though edible, have no highly nutritious properties, and are therefore of small sustaining value as a food. *Truffles* are a variety of fungi that we import from Italy, preserved in oil. They are used for poultry stuffing and for sauces and soups. The *Morel* is another fungus used in sauce manufacture; it grows in England to a limited extent, but is cultivated in Italy, whence our supplies come.

NECTARINE—See *Peach*.

New Zealand Flax—See *Phormium*.

Nux Vomica—A small tree (*Strychnos nux vomica*) that grows in India, Ceylon, Persia, and North Australia yields the seeds known as *nux vomica*, which play an important part in medicine. The seeds are flat, circular, smooth, and drab coloured. From three to five are embedded in the pulp of the orange-like fruit. They are extracted, washed and dried in the sun before being exported. They are strongly poisonous. They are used for dyspepsia, heart weakness, as a general tonic and stomachic, and to increase nervous energy. The official dose of the powdered nut is 1 gr. to 4 gr., but the drug is usually given as a tincture or as an extract in pills. The alkaloid which is the active principle is the strong poison *strychnine*. It is so rapid in its action that antidotes are seldom of value. The antidotes recommended are emetics, followed by washing the stomach with permanganate of potash solution or Condy's Fluid and by 4 dr. doses of bromide of potassium. Artificial respiration should also be tried.

OAK—There are numerous varieties of the oak [for which see the pages indicated in the General Index]. The species of highest importance is the British oak (*Quercus robur*), which is found in Europe and Asia and grows almost as far north as the Arctic circle. As a timber, oak combines hardness and toughness, hence its value. The "wooden walls of Old England" were the battleships built of oak. The introduction of iron and steel for ship hulls deposed oak from its supreme position in shipbuilding work. The durability of oak, even under water, is remarkable. The oak grows to great age and attains great size. The Newland oak, in Gloucestershire, had a circumference of 45 ft., and the extent of the spread of the oak is proverbial. Oak is extensively used for furniture and for wainscotting. It darkens with age, due to the action of the atmosphere upon the gallic acid which it contains. The darkened effect may be produced very quickly by exposing the wood to the fumes of ammonia. Wood so darkened is termed *fumed oak*, and the process is common in furniture manufacture. Oak is given to warping, but all varieties do not warp equally [see page 53]. It rusts when in contact with iron. The wood contains acetic acid, and 7·9 per cent. has been distilled from it [see page 5465]. Oak bark has an extensive use in tanning. *Bog oak* is oak which has become blackened by the action of iron salts in peat mosses where it has lain. Its enduring qualities in such a condition excel those of the natural wood. There are numbers of so-called oaks found over the world—Indian oak applied to teak, African oak, a hardwood of tropical Africa, and others.

Olives—The olive tree (*Olea europæa*), of which there is over a score of varieties, flourishes in warm but not in tropical climates. Extreme heat is as fatal to its successful cultivation as is extreme cold. The chief centres of olive cultivation are the countries bordering the Mediterranean, and from these we import preserved olives and the olive oil of commerce. Olive trees have, however, been introduced into America, Australia, and other countries held to be suitable to the cultivation, and moderate success has attended these enterprises. The olive tree grows on poor soil, and may be successfully cultivated on ground quite unfit for other crops. The soil should be dry, calcareous, and rocky, and drainage must be good. Hillsides are favourite situations for olive trees, and they are frequently cut into terraces. Propagation is effected by cuttings, by planting the root suckers, by seeds, and by grafting. Good strong manures should be used in olive farming, and should be applied annually if the soil is very poor, or biennially if it be of fair quality. Fruit is borne in the third or fourth year if regular pruning has been practised during the preceding years. The olive is a small, fleshy fruit, about the size of a grape, and contains one large hard-shelled seed. The best olive oil is procured from olives that are gathered before they are fully ripe. Fully ripe olives yield more oil, but of a lower quality. In its wild state, the olive tree bears fruit only every two years; but by careful cultivation, and by gathering the fruit regularly before it is fully ripe, annual crops can be secured. The fruit should be gathered by hand. The practice of beating the tree to cause the fruit to fall is common in some places, but it does serious injury to the branches, and impoverishes the succeeding crop. The yield of oil is from 25 per cent. to 50 per cent. of the weight of the fruit. The fruit is crushed, the stones or kernels being sometimes broken, and sometimes not, and then put into bags, which are put under presses in a warm room, where the oil is squeezed out. The marc, from which the oil has been pressed, is mixed with boiling water, and again pressed, the second expression yielding an oil of inferior quality. Olive oil is also known as *salad oil*, although many inferior oils are also sold under the latter name. Olive oil is sometimes given as a medicine, on account of its nutrient and laxative properties. It enters into the manufacture of Castile soap. The residue, or marc, after the oil has been extracted, is a valuable cattle food, and is also used as manure.

Opium—Opium is the dried milky juice from the unripe seed capsules of the opium poppy (*Papaver somniferum*). The cultivation and preparation of opium is an important industry in India, but it comes also from Turkey, Persia, and China. Attempts have been made to cultivate the plant in Europe, especially in France, and some of these attempts have been successful, although not commercially so. Incisions are made in the unripe seed capsules with an instrument that will not injure the seeds, and the juice flows out and coagulates. After a few hours it is removed with a knife and placed in inclined trays to drain. It is then dried somewhat in the sun, and comes to the Western market as a stiff, cohesive mass of dark brown colour. Upon the awful results of excessive opium eating and smoking we need not enlarge. The habit is the curse of China, and even in this country excess in drinking laudanum and preparations of morphia is too common. The drug (dose ½ gr. to 2 gr.) is a valuable remedy for pain, checking inflammation and nervous diseases, and benefits sufferers from cough, diarrhœa and dysentery. The liniment is use for rheumatism, neuralgia and sciatica. Internally it is given in numerous forms, chiefly as a pill and as a tincture known as laudanum (dose 20 to 30 minims.). For smoking, opium must be specially prepared. Of the three alkaloids of opium—morphine, narcotine, and codeine—the first is the most important (dose $\frac{1}{10}$ gr. to ½ gr.). It is administered in over a score of different preparations in addition to the powder. For an overdose of opium or morphine the antidotes are the stomach pump and washing out the stomach with a solution of permanganate of potash, also hot coffee, ammonia, or ether. The patient should not be allowed to succumb to the sleep induced by the drug, but should be made to walk until the narcotic effect has subsided. To cure the morphine habit it is recommended that the morphine solution should be replaced gradually by sparteine sulphate, ¼ gr. increased to ¾ gr. four to six times a day. *Poppy oil*, or *maw oil*, is expressed from the seeds of the opium poppy. It is used for artists' paints, as a salad oil, and as fuel and for soap manufacture.

Oranges—The common or sweet orange (*Citrus aurantium*) is native to China, and was introduced to Europe by the Portuguese in the sixteenth century. The best orange of the common varieties purchased in English shops is the St. Michael, which is thin-skinned, pale, and juicy, and has very few stones. The orange tree is very prolific in fruit, a tree fully mature may bear 12,000 oranges in one year, and cases are on record where over 20,000 have come from one tree in one year. Orange blossoms are white and fragrant, and from them is extracted

the essential oil—oil of neroli; but the natural oil has been displaced by synthetic oil of neroli [see page 4971]. Orange trees attain a great age, living for over 150 years. They have been successfully reared in the South of England in protected situations, but the expense attending such ventures and the poverty of the results have discouraged their further prosecution. The best flavoured oranges do not reach this country, because imported oranges must have been pulled when not fully ripe, and before they have reached their highest excellence. The mandarin, or Maltese orange (*Citrus nobilis*) is grown in China, in Malta, in the Azores, and elsewhere. It is a small fruit of oblate spheroid shape, with a loose skin, which, when fully ripe, may become spontaneously detached from the interior, allowing the latter to be shaken about loose within it. The fruit is exceedingly sweet, but does not keep so well as other varieties. Tangarine oranges are a variety of mandarin oranges. They are suitable for hothouse cultivation, and are prolific. The tree is small, being seldom higher than 7 ft. even in North Africa, the headquarters of their cultivation. Other varieties of the sweet orange are the Maltese blood oranges, a fine, large oval, rich blood fruit with dark red pulp; Majorca oranges, a seedless variety; Jaffa oranges, and a small kind known as *Kum-quat*, and coming from China and Japan. Seville or bitter oranges (*Citrus aurantium bigaradia*) are chiefly used for making marmalade. They are bitter, especially the rind, which is rugged and uneven. The fruit is round and dark coloured. The liqueur *Curacao* has bitter orange as one of its chief ingredients. The peel is pounded in a mortar under water, and after standing some time is distilled with alcohol. Sugar is added, and to some brands a special variety of rum. The rind of the bitter orange is also used for making candied peel [see page 4848]. Another bitter orange (*Citrus aurantium bergamia*) is grown in the South of France and in Sicily. Its only present use is for the expression of oil of bergamot [see page 4970].

PEACH—The largest and most delicious fruit of the plum family. In the English peach this fruit reaches its highest excellence, due to the care expended on its cultivation in this country. It grows best in loamy and calcareous soil, and benefits by the application of vegetable manure. The wall upon which peaches are trained should have a south-eastern exposure. Planting should be done about the end of November, and pruning should be regular in January or February. The trees should be about 14 ft. apart, and the fruit should not be closer than 6 in. There are three varieties of peaches—*clingstones*, *freestones* and *nectarines*.

Pea Nut—See *Ground nut*.

Pearls—Pearls are produced in the shells of several varieties of molluscs upon the introduction of a grain of sand or other foreign particle within the shell. Chemically, pearls are carbonate of calcium, and are built up in exceedingly thin layers, which show their characteristic iridescence by the interference of light. Attempts have been made to cultivate pearls by introducing a particle of sand within the pearl oyster shell, and leaving the animal to do the rest; but these experiments have not been crowned with conspicuous success, and practically all the pearls of commerce have been produced without the assisting agency of man. The chief sources of the salt-water pearls, which are the most valuable variety, are the *Aviculidae*. The most famous pearl fisheries in the world are in the Gulf of Manaar, in Ceylon, and other fisheries are in the Persian Gulf, in Queensland, and in California. Fresh-water pearls are of minor importance, commercially. They are formed by the *Unionidae*, fresh-water molluscs. The rivers of Scotland were formerly of some importance in supplying pearls, and a few come from there now; but fresh-water pearl fishing is not a regular industry as marine pearl fishing is. Taking the Ceylon pearl fisheries as illustrative, the fishing lasts for only a few days annually, and native divers descend from boats, relieving each other frequently. The pearls are sorted out into well-defined classes, according to lustre, shape, and size. Some oysters have the interiors of their shells lined with the pearlous substance known as mother-of-pearl, and many of the fisheries are conducted for the mother-of-pearl only, although pearls are also got in these places in small quantities. The best mother-of-pearl comes from the fisheries of the coast of Queensland, and other important sources are the seas of the Indian and South Pacific ocean. Commercially, mother-of-pearl has a ide th buttons, studs, fans, and other articles as well as for inlay work. Artificial pearls are now an important article of commerce, and the best of them are made from the scales of the bleak fish.

Phormium—Phormium fibre, or New Zealand flax, is an important cordage fibre which will attain a higher place industrially than it holds to-day. It is soft, white, and lustrous, and its strength is said to be greater than hemp or flax. The percentage of fibre yielded by the plant is high, being as much as 15 per cent. of the green plant. The preparation comprises crushing between heavy rollers, pounding of the crushed leaves by beaters on a revolving drum, washing in running water, and drying and bleaching in the sun. [See also page 817.]

Piassava—Piassava, or piassaba, is the "bass" of our broom manufacturers, and is the most important material used for stable and street brushes. The fibres are black or dark brown, and reach this country in bundles. They come from the leaf stalks and leaf sheaths of large palms that grow in South America and tropical Africa; the best is Bahia piassava. The tree grows wild, and is propagated naturally by its nuts. It is not cultivated. The unopened leaves are enveloped by coarse fibres of chocolate colour, which the natives remove with axes. The fibres are then combed out, straightened, and cleaned—all simple manual processes—and finally packed in bundles of about 30 lb., which again are made into bales of 80 lb. to 100 lb. for shipment. Locally a rope is made from the fibre, but its only use in Europe is for brushes. Para piassava is another variety from Para. African piassava and Madagascar piassava are coarser. [See also page 6106.]

Pimento—Pimento, or allspice, is the dried unripe fruit of *Pimento officinalis*, a tree that grows in the West Indies, Mexico, and South America. The chief source is Jamaica. An illustration of pimento appears on page 4720, and a brief account on page 4722. The fruit consists of black or deep purple berries with a smooth and glossy exterior. It is picked by hand when fully grown, but before it is ripe, and is spread out on floors to dry, a process which takes about a week. The popular name of allspice arose from the fragrance of the berry being thought to resemble a blend of various other spices. The wood of pimento is used for walking-sticks and umbrellas.

Pineapple—The fruit known as the pineapple grows on a tree (*Ananas sativa*) native to tropical America. To successful cultivation a long hot summer and absence of frost in winter are essential. Most of the pineapples entering the British market come from the Azores. The fibre of the plant has a limited value for textile fabrics [see page 818]. The inhabitants of Formosa and China use it for a coarse fabric, and the Piña cloth of the Philippines is also made with it. The leaves of the plant are scraped with a piece of sharpened bamboo, or with the edge of a broken piece of pottery. The fibre is then washed and sun dried, issuing soft, white, flexible, durable, and water resisting. It is then spun and woven.

Pisang—See *Banana*.

Plane—The plane tree (*Platanus orientalis*) is a hardy tree, growing well in a city atmosphere. It has a smooth, grey trunk, with a bark that scales in flakes, and large five-lobed serrated leaves. The Western plane (*Platanus occidentalis*) is not quite so hardy. It is called *sycamore*, and sometimes *buttonwood* in the United States; but it is not the same tree as our common sycamore (*Acer pseudo-platanus*), which is abundant both in Europe and North America. All varieties yield a fine, easily-worked white wood, extensively used for general purposes.

Plantain—See *Banana*.

Plumbago—See *Graphite*.

Podophyllin—Podophyllin is the resin of the root of *Podophyllum peltatum*, a plant that grows in Canada and the Eastern States. It is the American mandrake, or May apple, and is sometimes called *vegetable mercury* from its value as a biliary purgative. It is given also as a laxative and as an aperient. Podophyllum comes to the drug market as flattened root stems, and the resin is extracted in the drug shops by precipitation by means of acidulated water from an alcoholic solution. The result is a greenish brown powder of a decided odour and acrid taste, soluble in aqueous ammonia and almost entirely in alcohol. The dose is ¼ gr. to 1 gr. It is made into pills, tablets, tincture, and extract.

Poplar—The most common varieties of poplars are the white poplar (*Populus alba*), the black poplar (*Populus nigra*), and the aspen (*Populus tremula*). The wood of the poplar is soft, has a fine grain and a silky appearance, and is easy to work. For strength of the wood, see page 1260. The *cotton wood* of the United States is a variety of poplar, and *yellow poplar* is a name applied to white wood.

Poppy Oil—See *Opium*.

Prince Wood—See *Elm*.

Prunes—The prune is a variety of plum. It is cultivated in America, France, and several Mediterranean countries. It is a hardy tree that flourishes in a rich, moist soil, but by suitable grafting it can be grown on other soils. Sun-dried prunes are picked when fully ripe; they are peeled, strung upon twigs, put into straw frames, and suspended in the sun. After a preliminary drying the

stones are removed, and the prunes are then made thoroughly dry in the sun. In France, prunes not yet fully matured are placed in boiling water, then transferred to baskets, and agitated till cool, then completely dried by exposure to sun heat.

QUINCE—The quince (*Cydonia vulgaris*) is a fruit similar to the medlar. It has been grown in the Mediterranean countries since pre-Christian times, and, while not edible on account of its bitterness, is extensively used in the manufacture of jelly. The word *marmalade* is said to be derived from *marmelo*, the Portuguese word for quince. It is also cooked with apples and other fruits. The tree is used as stock for pear-trees in this country.

RAISIN—Raisins are dried grapes. Sultana raisins come from Smyrna, and Damascus raisins from Damascus. Both are stoneless varieties, the latter being the larger. The ordinary raisins of commerce come from Valencia. The usual method of drying these varieties is to expose them to the sun and air, and then to spread them out in rooms, sprinkling them with aqueous solution of potash or soda, which causes the formation of grape sugar, the small sweet accretions found on the fruit as purchased. *Muscatels*, which come from Malaga, are a variety of raisin that are dried while still hanging from their branches, the leaves being pulled off and the branch cut half through until the fruit is dry and ready for packing.

Ramie—The three names *ramie*, *rhea*, and *China grass* are used commercially without distinction for two fibres. Rhea, or ramie, is the fibre from the stems of *Boehmeria nivea tenacissima*, a large plant of the nettle order. It grows only in hot climates. The related plant, *Boehmeria nivea*, grows in temperate as well as tropical climates, and is properly *China grass*. In China, China grass is prepared for the market by manual labour, the outer skin being scraped and washed. The process of degumming—the need for which has prevented ramie from taking a very high place among textile fibres—is usually carried out at the mills whither the fibres are sent. [See page 1390.]

Raspberry—The raspberry (*Rubus idæus*) is a well-known fruit that grows wild in temperate Europe and is also extensively cultivated. Shoots spring from the root every spring, bear fruit in the summer of the following year and die in the autumn. The soil should be well manured and deeply trenched. The plants are usually 2 ft. apart in rows, each row being about 5 ft. from its nearest neighbour. They may be tied up with stakes or trained to a trellis of wire running along the row. Pruning consists in removing the excess stalks, leaving from three to five of the best and in cutting off the growths that are not in a position to be supported. The canes are cut short, but not too short, in spring, and any side branches induced to carry fruit. Autumn fruiting raspberries are pruned differently; in January the canes are cut to the ground and in spring those that have sprung are cut, leaving not more than four. Do not shorten the canes at all as only the upper portion bears fruit.

Red Currants—See *Currants*.

Redwood—See *Cedar*.

Resins—Resins are thickened plant juices insoluble in water, but soluble in alcohol and oils. Substances from kindred sources and soluble in water are known as *gums* [see *Gums*], although many resins are known as gums. Resins are usually found in plants that yield essential oils; for instance, common resin, or rosin, is found in pine trees, the essential oil of which is turpentine. The principal resins of commerce are as follow: Resin, resin, or colophony [see page 1034], amber, gamboge, copal, sandarac, camphor, dammar, mastic, benzoin, and tolu. Particulars of these are given under their respective names. Shellac is also a resin, although it is produced as an incrustation upon certain trees by the help of an insect [see *Shellac*].

Rhea—See *Ramie*.

Rhubarb—Rhubarb is a perennial plant cultivated for its leaf stalks, which are used for making jam and wine. It is usually propagated by division of the root, and flourishes best in rich, deeply dug soil. It is often forced by being covered with flower-pots, which are covered with stable manure which ferments and supplies heat. The rhubarb of medicine is the root of a plant (*Rheum palmatum*), larger than our garden rhubarb. It is grown chiefly in China and Tibet, and although the most esteemed variety is known as Turkey rhubarb the name has nothing to do with its source. Attempts to grow medicinal rhubarb in Europe have met with some success. As a drug it is given in powder form (dose 15 gr. to 30 gr., or if repeated, 3 gr. to 10 gr.). Compound rhubarb powder is generally known as Gregory's powder. Rhubarb is also administered as extract, as pills, as a syrup, and as a tincture. Its effect is laxative, and it is freely given for stomachic disorders.

Rice—For the cultivation, preparation and food value of rice the pages referred to in the General index should be consulted. Here we shall mention only some of the uses of rice which are not mentioned in other pages. In Japan, rice straw, besides being used as cattle fodder, is plaited into hats and shoes for men and horses. The bran and dust are also used as cattle foods, as stated elsewhere. The chaff from rice forms a good manure. Rice powder, or *poudre-de-riz*, is sometimes deceptive as it is frequently merely finely powdered soapstone, although a genuine rice powder is also sold as a complexion powder. The Japanese make an alcoholic drink named *saké* from rice by soaking it and inoculating with the fungus *Aspergillus oryzal*, which produces a ferment, and after several processes of fermentation yields a beverage named as above, and containing about 13 per cent. of alcohol. The Chinese and the Malay natives also manufacture alcoholic beverages from rice. *Wild Rice* (*Zizania aquatica*), is a wild plant that is extensively found in America as well as in Asia. It flourishes in muddy soil under shallow water. Attempts to cultivate it by Americans have not been conspicuously successful, but, under the ægis of the Department of Agriculture, experiments are proceeding.

Rosewood—The rosewood of the cabinet-maker has nothing to do with the English garden rose, and derives its name from the odour resembling that of the rose to some extent. It is the timber of certain Brazilian trees, notably *Dalbergia nigra*. Other varieties of so-called rosewood come from Jamaica, Dominga, Burma and New South Wales. *Jacaranda* wood is a name sometimes applied to the Brazilian *Dalbergia*. Rosewood is hard and even in the grain, has a fragrant odour, and a colour ranging from purple-brown to black. It is a high-class wood in furniture-work and for piano cases.

SANDAL-WOOD — Sandal-wood is the heartwood of several species of *santalum*, and is esteemed for its aromatic properties and for the essential oil that it yields. The chief source is India, but it is also found on some of the Indian and South Sea Islands, and in Western Australia. The Indian tree is the *Santalum album*, and the forests where it is cultivated are usually Government reserves. After the tree is felled it is allowed to lie for some months, during which time white ants devour the sap wood, which is of no value. The heartwood is then cut up and conveyed into the stores. The chips from this cutting-up and the sawdust is used for essential oil distillation [see page 4970]. Sandal-wood is made into trinket-boxes in India, and is easily recognisable from its fragrance and dark cedar colour. It is also burned as incense in religious ceremonies. Sandal-wood oil is extensively used in medicine for chronic bronchitis and other diseases. It is given in a variety of forms.

Sandarach—Sandarach, also known as gum sandarach and erroneously as *juniper gum*, is the exudation of the North African tree (*Callitris quadrivalvis*), and is much used for fine varnishes. It is used as a varnish for coating pills.

Satinwood — Satinwood (*Chloroxylon swietenia*) comes from both the East and West Indies; that from the East is figured, while West Indian satinwood is not. It is a beautiful hard wood, of yellow colour, and is valued in cabinet work. It is not obtainable in large pieces, the usual size of log imported being about 10 ft. long and 7 in. or 8 in. square.

Senna—The leaves known as senna are used in medicine as a purgative. There are two varieties—Alexandrian senna, the leaves of *Cassia acutifolia*, which are collected by the Arabs in the neighbourhood of Suakim, and East Indian or Tinnivelly senna, the dried leaves of *Cassia angustifolia*, which are cultivated in Southern India and are longer, narrower, and lighter in colour than the Alexandrian senna. Senna is administered as an infusion, an elixir, a confection, and in other preparations. Compound liquorice powder is one-sixth part senna. The American medicinal drink known as Garfield tea contains senna.

Shaddock — The shaddock (*Citrus decumana*) is a large fruit of the orange family, and is largely cultivated in the Malay peninsula and Southern Asia, and in some of the Oceanic islands. It has a smooth, pale yellow skin, and a white or reddish pulp. It sometimes weighs from 10 lb. to 20 lb., the flavour resembles that of the grape, and hence it is often called the grape fruit. The West Indian grape fruit is another variety of the Asiatic shaddock.

Shellac—Shellac is the most common resin used for varnish manufacture, and is also used for sealing wax and forms an excellent natural cement. It is formed on the branches and twigs of a large number of Indian trees by the lac insect (*Coccus lacca*). The incrustations are removed and melted in boiling water, afterwards being poured upon a cold surface, where they take the form of thin, irregular flakes. *Ground shellac*, also known

under half-a-dozen other names, is the resin of the Australian *Xanthorrhœas*. It is used for varnish, for staining wood, and also in the manufacture of picric acid.

Sisal—The fibre known as sisal hemp ranks second only to Manilla hemp as a strong cordage fibre. There are two varieties of sisal, the *Agave rigida elongata* of Yucatan, and the *Agave rigidi sisalana* of Florida, Cuba, and the Bahamas. The latter is the more important, and is known also as *henequen*. The sisal has recently been introduced into India and British East Africa, and the foundations of new industries laid in these colonies. The plant flourishes in any stony soil rich in limestone. The treatment of the growing plants and of the fibre-yielding leaves is similar to that of Manilla hemp. After preparation, the fibre is a straight, pale yellow ribbon from 2 ft. to 4 ft. long. Other plants of the same order are the *American aloe* or Century plant, the *Istle* or Mexican fibre, and Mauritius hemp. These are inferior to the true sisal.

Slate—Slate is a clay that has been folded and compressed in its bed, so that it can be split readily into thin and uniform plates. Slates differ in colour according to locality. The slates of the Lake District are greenish; Cornwall slate is grey. The best known slate quarries in this country are the Penrhyn quarries near Bangor, in North Wales; in Scotland the most important source is Ballachulish, and in Ireland, slates are obtained at Valentia and Killaloe. Slate is obtained by sawing large blocks in their beds, and these are sawn up into lengths, either machinery or hand saws being used. Slate splitting is done by hand, the tools employed being thin, broad-faced wedges and wooden mallets. In winter-time slates may be split by the natural action of frost, water being poured over the blocks, and when this expands by freezing fracture occurs along the natural plane of cleavage. The chief use of thin slates is for roofing purposes, and they are the most widely used roofing material in this country. Superior qualities are used for writing-slates; and the manufacture of writing-slates is an important industry in North Wales. In thick slabs slates are used for the beds of billiard-tables and for cisterns, and when painted with special enamels and fired, slate forms chimney-pieces made to resemble the different veinings of marble. The hones used for sharpening knives and edge tools are varieties of slate. Much of the supply of hones comes from abroad, Turkey hones, esteemed for edge tools, coming from Asia Minor. Of recent years the chief supplies of hones have come from the United States.

Sponges—Sponges are the elastic skeletons of marine animals, *Porifera*, which inhabit the seas of Europe, America, Africa, and Asia. Sponges grow in seas where the temperatures of summer and winter do not vary much, and in the zone where they are found the best are those where the climate is most nearly uniform and warm throughout the year; those which are on the outer edges of this zone, and which, therefore, are in a climate varying towards the temperate, are coarse and poor in quality. Sponges are most prolific along the shores of islands, and where there are fairly strong ocean currents, which seem to convey to the animals the materials of sustenance. Attempts have been made to improve the culture of sponges by cuttings, but it has not been proved that this increases the number of sponges beyond that produced without cutting. Sponges always grow on hard substances, such as rocks, reefs, and the stems of marine plants. The best are in deep water, and the poorest qualities in shallow water near the shore. The sponges are collected by the use of "harpoons," or thin long poles, with which they are dislodged by divers; or by dredging with a drag net. Sponge divers sometimes work naked, and sometimes in a special dress. If the former, they carry a block of stone to enable them to descend. A diver can remain below for 3½ minutes, but not longer, and usually descends about 20 fathoms. Sponges, when collected, are alive; they die within 24 hours of having been exposed to the air and then the animal remains must be removed so as to leave only the skeleton sponge. The skin is removed, sometimes with a knife, and kneading them, or stamping them out with the feet, gets rid of most of the other animal matter. Then they are washed and dried; they must not be packed before they are dry, or they will spoil. Sponges may be bleached, but the process impaires the durability and purchasers should avoid bleached sponges. There are many varieties of sponges due to different localities. The chief varieties sold are named Turkey and honeycomb--the former being the small-holed, close variety of flat or cap shape, and the latter being the large-holed variety, which is also usually of a paler colour.

TEAK—Teak is the chief wood exported from India and Burma. It is found also in Siam, Java, Cochin China, and in some of the islands of Dutch East India. Teak is the timber of trees of the genus *Tectona* or *Theca*, the Indian teak being *Tectona grandis*. The trees are very large, having trunks 80 ft. to 90 ft. high before the first branch is reached, and a circumference of 20 ft. to 25 ft. The timber is hard, and brown or yellow-brown in colour. Its water-resisting properties make it valuable in shipbuilding. [For strength of teak, see page 1260.]

Tolu—Tolu is the resinous balsam of *Myroxylon toluifera*, a tree that grows in most South American countries. It is bronze yellow in colour and is syrupy when collected, but becomes hard and brittle. It is used in perfumery; and in medicine in its natural state (dose 5 grammes to 15 grammes), and as a syrup, and a tincture. Its chief value in medicine is for coughs and bronchial irritation.

Tortoiseshell — Tortoiseshell is the horny back covering of the *hawk's bill turtle* [see *Turtle*]. The shell from a single animal may weigh up to about 8 lb. For ornamental purposes tortoiseshell has a wide use, and is made into combs and other articles of use and ornament. In its natural state it is very thin, and it is necessary to join together several shells so as to attain thickness. The shells are boiled or are heated in oil, when they become soft, and may then be moulded to any desired form or welded together into intimate union.

Turtles—Turtles are marine animals belonging to the order *Chelonia*. Two of the species are commercially important—the hawk's bill turtle (*Chelone imbricata*), which inhabits tropical seas, and which furnishes tortoise-shell [see *Tortoiseshell*], and the edible or green turtle (*Chelone midas*), which is found throughout the Southern oceans, and particularly near the Bahamas. The green turtle sometimes weights up to 5 cwt. or 6 cwt., and may be as long as 5 ft. Its fat is of a green colour, hence its name. Its use is for the turtle soup, and the consumption is large, especially in London. In the Bahamas, when the turtles land to deposit their eggs, they are simply turned on their backs and are incapable of turning over again. The Chinese catch turtles with a sucking-fish, to the tail of which they attach a string; the fish fastens upon a turtle, and both turtle and fish are drawn into the boat.

VANILLA—Vanilla is the cured pods of *Vanilla planifolia*, a climbing plant native to Mexico, but now grown in Ceylon, Mauritius, and other parts of the globe. Other varieties of plants contribute to the supplies of commercial vanilla, but that mentioned is the chief. The pods are developed only after the flowers have been fertilised, and artificial pollination is practised to increase the yield. The pollen is placed by hand upon the stigma, a small pointed cane being used for the purpose. The pods are cured, and this develops the flavour, the curing process consisting in immersing them into water almost at boiling point, and immediately withdrawing them and putting them into baskets lined with blankets, afterwards drying them in heated rooms. The active principle is vanillin. An artificial vanillin, made from sugar, is one of the recent triumphs of modern chemistry.

WALNUT—The walnut tree (*Juglans regia*) grows extensively in North Europe and Asia. For uses and strength of the timber, see pages 57 and 1260. Great Britain imports the walnuts from Italy, Germany, and France. Before being packed they are dried in a kiln, a process that preserves them but injures their flavour. American walnut, or black walnut (*Juglans nigra*), is valued for its appearance, and is used for furniture, both solid and as veneer.

Whalebone—Whalebone is not bone, but is the substance of the nature of bristles with which the mouths of certain varieties of whales are furnished in order that they may catch and crush the small fish and sea animals on which they feed. Whalebone resembles hardened hairs cemented together, and in its characteristics is more like horn than bone. There are several species of whalebone whales both in the Northern and in the Southern seas. A Greenland whale of full maturity provides about a ton of whalebone. The sides of the upper jaw are the places where the whalebone is found, and each side usually has about 300 blades, which are from 12 ft. to 15 ft. long, being longest in the middle, and 10 in. or 12 in. broad at the base, with a thickness of not quite half an inch. Before being cut up, the blades are cleaned and softened by being boiled for a few hours, and are then, while still hot, planed or shaved by hand, the tool used resembling a spokeshave. After being planed, the whalebone is polished, usually with the edge of a piece of glass or a steel scraper, then with emery powder, and finally with powdered rottenstone. Commercially, the value of whalebone lies in its elasticity, flexibility, and strength. The roots of the blades, where they are thickest are used in the manufacture of walking-stick and umbrella handles, and other purposes. The use of whalebone as a material for the ribs of corsets is practically a thing of the past, as it has been superseded by steel.

Concluded

Plates and Frontispieces in the Self-Educator

Special Contributions

THE SELF-EDUCATOR AT A GLANCE

A CONSPECTUS INDEX ARRANGED IN ORDER OF THE GROUPS, BEING A READY GUIDE TO THE WHOLE CONTENTS OF THE SELF-EDUCATOR

All the Articles in the Self-Educator are briefly summarised in the following pages, under the groups, sub-groups, and sections to which they belong and in order of publication. This affords a brief general survey of the branches of knowledge and also gives an easy means of obtaining a general idea of the scope and nature of the artic'es. Sections of the groups are indicated by side-headings in italics. For particular subjects or items of information, reference should be made to the General Index, beginning on page 6900. A list of plates and frontispieces is given on page 6892.

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SELF-EDUCATOR GUIDE TO KNOWLEDGE

A COMPREHENSIVE INDEX TO ALL THE SUBJECTS TREATED IN THE SELF-EDUCATOR

This Index is entirely alphabetical and unclassified, so that reference to it is a simple matter. Any item of information in any subject should be looked for as if the Index were an index to that subject alone, French adjectives, for example, under "Adjective," not under "French"; dynamo brushes under "Brushes," not under "Dynamo." This principle has been followed as far as possible, though, of course, general information in regard to the French language or dynamos is indexed under "French" or "Dynamo." For general surveys of the subjects treated in the Self-Educator, see the Group Index, beginning on page 6893. Page references in italics indicate illustrations. Chemical compounds are indexed under their exact names—e.g., Sulphate of Copper under "Copper Sulphate," with a cross reference for the popular name, Blue Vitriol. Owing to exigencies of space, the numerous dictionaries in the Self-Educator have not been separately indexed. They will be found by reference to the particular subjects.

END OF VOLUME VIII.

The Editor's Last Page

SOMETHING of the sadness of parting creeps into this final page of the SELF-EDUCATOR. The EDUCATOR is now complete. In saying this the thought comes that, after all, we live in a human world. We may aim high and plan long, we may mean well and do well, and yet our path, as we look back upon it, may be strewn with the wrecks of our desires and with shattered hopes. As we look back to the beginning from the end, we see that it could all have been better. We can all say that when the end of anything comes. There would be nothing worth having in experience if we could not.

I am not going to proclaim the faults of the SELF-EDUCATOR from the editor's desk. They are seen there, perhaps, as they can be seen from no other point of view. It is enough for an editor to say that he tried to be perfect and could not; it is all that an editor can hope that his mistakes are not too many for human readers to forgive.

It is pleasant that with all the regrets which retrospect brings there comes a grateful sense of satisfaction. I have not lived long, but I have come to know that nothing in the world is so grateful to a man as success. I did not mean to write "success," but let us be honest and not be afraid of a word. Success is not everything. I would rather have experienced some failures, with all their bitterness and tragedy, than have reaped some of the successes that flaunt themselves blatantly before the world. But we need not be ashamed of success in well-doing, and there is too much false righteousness preached against those who urge young men to succeed. It is not the wise man who wants to fail, and if our life is set in the right path, if our hands are clean and our work is good, let us never for one moment feel that we ought to be ashamed to want success.

And the EDUCATOR has succeeded. There was room for such a book, and it must be better for us, better for our work, better for our lives, better for England, that there should be a vast thinking public with the EDUCATOR on its bookshelves.

It would take the whole of this number to say "Thank you!" to all to whom thanks are due. If, as this last page goes to the printers, I could remember all those with whom it has been a pleasure to come into touch, there would not be room, if I could find the words, to say all that I would say.

Such a publication reaches into a thousand fields. There comes to mind a letter from a lonely boy on the Canadian prairie, who had read of the SELF-EDUCATOR, and wondered how he could get it. There comes to mind, too, the Egyptian boy in Cairo whose two sets of the EDUCATOR have given us such trouble as can only be balanced, let us hope, by the pleasure they have given him. All over the world in the future travellers will come across this work.

There must also be thanked a vast number of correspondents who have been unwearying in their desire for the success of this work, the thousands of readers who have made its success possible, the schoolmasters who have commended it to their schools, those who have asked for an extra volume or suggested extension in other ways that were not possible without the approval of all readers. It is right, also, that it should be known how loyal and helpful the booksellers and newsagents have been. The contributors, the real makers of the EDUCATOR, can never be better rewarded than by the striking public appreciation of their work; but it is due to them to say that, with one or two exceptions, they have proved themselves highly capable, interesting, and the soul of courtesy and forbearance.

One other note of thanks is due. Behind every great work is an army of unknown workers. The editor's name is blazed abroad, but a thousand names remain unknown of those without whose aid an editor's work would never be done. The production of the EDUCATOR has been exceptionally difficult as a result of the effort to keep the work up-to-date instead of allowing it to be produced, as most encyclopædias are, so that it is out of date on its completion. To authors, editors, artists, photographers, printers, newsagents, and a host of other workers the production has for this reason been unusually trying, and especially has it been a strain upon the immediate editorial staff. To my friend and colleague, Mr. J. A. Hammerton, whose short introduction to English literature is one of the essential values of the EDUCATOR, and to all those other members of the staff whose loyalty and hard work have helped to make a burden light, the indebtedness of the SELF-EDUCATOR should be acknowledged.

To them, and to all whom it may concern, I give now that deep and grateful feeling of which our language has but one expression—Thank you!

ARTHUR MEE

The next book in the Self-Educator series is the HARMSWORTH HISTORY OF THE WORLD

THE WORLD'S GREAT MEN

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COMPRISING

Biographies of Men and Women, of All Countries and in All Times, who have Contributed to the Welfare of the World in Art, Science, Literature, Travel, Invention, Statecraft, or Other of the Varied Activities of Life

Edited by ERNEST A. BRYANT

THE WORLD'S GREAT MEN

Abbas I., the Great
b. 1557. d. 1628

A man who, in spite of many crimes, was one of the greatest of Persia's sovereigns. Successfully rebelling against his father, he put to death one or more of his brothers, and ascended the throne in 1587. Suppressing lawless soldiery and a feudal nobility which menaced the throne, he embarked upon a brilliant career of conquest, and was assisted by a British fleet to wrest Ormuz from the Portuguese. At his death the Persian Empire had been extended from the Tigris to the Indus. Terrible cruelties were practised at his behest, but his system of government was enlightened and praiseworthy.

Abel, Sir Frederick August
b. London, July 17 1826 d. London, September 6 1902

Among the first students of the Royal College of Chemistry, he became, at twenty-seven, chemist to the War Office and chemical referee to the Government. He divested the preparation of gun-cotton of danger, and paved the way for smokeless powder, of which cordite invented by himself and Sir J. Dewar was adopted by the Government. His petroleum investigations determined the standard for flash-point; while in electricity and steel manufacture he won a special standing. He was President of the British Association in 1890.

Addison, Joseph
b. Milston, Wilts, May 1, 1672 d. Kensington June 17 1719

"Whoever wishes to attain an English style, familiar but not coarse and elegant but not ostentatious, must give his days and nights to the volumes of Addison." Dr. Johnson's estimate of our foremost light essayist still holds good. Obtaining through his patron, the Earl of Halifax, a pension of £300, he spent four years on the Continent, after which his poem, "The Campaign," celebrating the victory of Blenheim, secured him an Excise Commissionership. While secretary to the Lord Lieutenant of Ireland he formed a close friendship with Swift. The "Tatler," started by his friend Steele, had Addison among its regular contributors; as had the "Spectator," founded two years later. A quarrel with Pope led to his being satirised by the latter as Atticus. Appointed a Commissioner for Trade and the Colonies, he was embroiled in disagreement with Steele. Three years before his death he married Charlotte Countess of Warwick. His fame rests not upon his poetic or dramatic writings, but upon the essays which caused him, while recognised as a contributor to the gaiety of the nation, to be hailed as "Guilt's chief foe."

Adrian IV. See Breakspear, Nicholas

Æschylus
b. Eleusis, Athens, 525 B.C. d. Gela, Sicily, 456 B.C.

The father of Greek drama was born of noble family, and before giving his mind wholly to poetry, shared with his brothers the perils of war against the Persians. His successful first appearance in the dramatic contest was in 484, when he won the prize with the trilogy of which the "Persians" formed part. Afterwards he enjoyed a series of thirteen victories, interrupted by the advent of Sophocles. This defeat, coupled with indignation at the doubts cast upon his piety, caused him to retire to Sicily, where, after other poetic triumphs, he died. Only seven of the sixty plays ascribed to him are extant, but these place him on a pinnacle of unapproachable height.

Æsop
b. Phrygia, Asia Minor, 620 B.C. d. 561 B.C.

For neither date can there be any pretence at [illegible]. Very little is known of the immortal fabulist beyond that he was born a slave in Phrygia, and sold eventually to Jadmon the Samian, by whom he was freed. He visited the Court of Crœsus, by whom he was sent on various missions, which enabled him to travel in Greece and Asia Minor, inculcating morals by his fables. He is said to have met his death through being thrown over a precipice by the priests of Delphi.

Agassiz, Jean Louis Rodolphe
b. Motiers, Switzerland, May 28, 1807 d. Cambridge, England, Dec 14, 1873

An indefatigable naturalist, whose writings, when he was twenty-six, won the praise of Cuvier. His work on the glacial phenomena of the Alps, on fossil fishes in Europe and the American Continent, his lectures at various seats of learning, and his gifts of priceless collections, did much to advance the science to which he devoted his life.

Agha Muhammad Khan Kajar
b. 1740 d. Shishah, Persia, 1797

After Persia had been for many years torn by civil war, he acquired the sovereignty in 1794, and founded the existing dynasty. He promoted commerce and reforms, but was one of the cruellest monsters that ever wore a crown. Mutilated himself early in life, he treated his enemies with frightful barbarity. Once, after ordering a general massacre of women and children, he had 70,000 eyes of his subjects put out. He was assassinated in 1797.

Agricola, Cnæus Julius
b. Fréjus, France, 37 A.D. d. August 23, 93 A.D.

He thoroughly conquered Britain and a great part of Scotland; he gave the land wise laws, and induced the Britons to embrace Roman manners, and to have their children taught the Latin tongue. Also, he enriched the land with many noble buildings. He was the first to discover that Britain is an island. Recalled and humiliated by the jealous Domitian, he died at the age of fifty-five. Tacitus was his son in law.

Ahmed Shah
b. 1724 d. 1773

The first sovereign of Afghanistan was in his youth in the service of Nadir Shah. Upon the assassination of the latter he retired to Kandahar, and persuaded the native tribes to assert their independence and make him king. He proved a talented military leader. The Koh i-Nur was one of his many rich possessions.

Aird, Sir John, Bart., M.P.
b. London December 3 1833

The son of a working man, Sir John Aird has raised himself by industry, integrity, and genius to the rank of one of the foremost contracting engineers in the world. His greatest work is the Assouan dam, the reservoir in connection with which holds 80,000,000,000 gallons of water.

Alaric I.
b. 376 d. Cosenza, Calabria, Italy, 410

Chief, afterwards King, of the Visigoths, Alaric, though the leader of barbarians, was himself an Arian Christian. Although the great general Stilicho defeated him, he proved the foremost military commander of his age. He pillaged Athens; thrice besieged, and once, for six days, sacked Rome; deposed its Emperor, and set up another. Many barbarities were practised by his troops, in spite of his humane intentions; but he caused women to be spared and religious buildings to be preserved. At his death the river Busento was diverted from its course that he, with all his treasure, might be buried in its bed. The work completed, those who had carried it out were put to death, that the secret might be maintained inviolate.

Alcibiades
b. Athens, 450 B.C. d. Phrygia, Asia Minor, 404 B.C.

This famous general and statesman came early under the influence of Socrates, who saved his life in battle, to be himself rescued by Alcibiades at the battle of Delium. Brave and talented, Alcibiades lacked mental ballast. Mutilation of votive statuary in Athens caused him to flee into Lacedæmon, and thence to Persia, to be recalled in triumph to Athens. His military expeditions culminating finally in disaster, he passed into Phrygia, where, by Spartan orders, he was assassinated—his house being fired, and himself struck dead by darts as he emerged

Alexander the Great
b. Pella, Macedonia, 356 B.C. d. Babylon, [illegible]

The son of Philip of Macedon, Alexander, educated by Aristotle, was regent of his father's kingdom at sixteen, at eighteen won his first battle, and two years later became king. Having subdued the Greeks and consolidated his power in Europe, he, in 334 B.C., with 30,000 foot and 5,000 horse, crossed into Asia, never to return. Defeating the Persians, he took Tyre, conquered Syria and Egypt, and founded Alexandria; defeated Darius, conquered Parthia, Media, and Bactria, invaded India, and over-ran Asia; then returned to Babylon, where he died from the effects of excessive drinking. Many appalling crimes tarnish his fame, but his influence for good was felt for centuries; for he caused to be diffused far and wide Greek art, science and philosophy, and gave an impetus to learning where barbarism in its worst forms had reigned. He left no successor, and at his death his vast empire was divided among his generals.

Alexander II. of Russia
b. April 29, 1818. d. St. Petersburg, March 13, 1881.

The son of Nicholas I., who upon his death-bed exhorted him to free the serfs, Alexander nobly carried out that mandate, and six years after his accession, emancipated 23,000,000 of his subjects. Russian territory was widely extended during his reign, which ended in a great tragedy. The Nihilists, who had thrice attempted his life, assassinated him on the very day upon which he was to have signed a Constitution for Russia. His eldest daughter married Queen Victoria's second son, the Duke of Edinburgh.

Alfieri, Vittorio
b. Asti, Italy, January 17, 1749 d. Florence, October 8, 1803

The son of a noble house of Piedmont, Count Alfieri led for some years a life of indolence and luxury, but in middle age made himself master of Latin and Greek. He wrote many tragedies and comedies, some of which still keep the stage. Their effect was to popularise a purer Italian literature.

Alfonso X., the Wise
b. 1226. d. 1284

Succeeding his father as King of Leon and Castile, he won victories over the Moors, and united Murcia to Castile. With him Castilian literature had its birth. He caused the first general history of Spain to be written, and the Old Testament to be for the first time translated into Castilian. His life was embittered by the rebellion of his sons, of whom Sancho eventually deposed him.

Alfred the Great
b. Wantage, Berkshire, 849 d. October 27, 901.

The wisest, best, and greatest King that ever reigned in England was the fifth and youngest son of Ethelwulf. His reign was one long struggle with the Danes, who, upon his accession, in 871, were masters of practically the whole of England north of the Thames. He waged war with varying fortune until finally he made himself King of all England. Such is the veneration in which his memory is held that it has been customary to ascribe to Alfred every privilege which Englishmen enjoy. What he did was to codify the best laws enacted by his predecessors, to found a Navy, encourage learning and industry, and, for the first time, to consolidate England into a united monarchy. His will, a notable document, is preserved, but it is not known where, or from what cause, he died.

Alleyn, Edward
b. London, September 1, 1566 d. London, November 1626

An actor famous as a contemporary and neighbour in London of Shakespeare, in whose plays he frequently performed. Successful theatrical speculation, reinforced by money gained by marriage, enabled him to buy for £10,000 (worth now five times that sum) the 1,300 acres with which he endowed his College of God's Gift at Dulwich. The value of the property, which is constantly increasing, is now upwards of two millions sterling.

Amadeus VIII.
b. Chambery, France 1383 d. Geneva, 1451

He caused Savoy to be erected into a duchy, then ruled Piedmont, but relinquished temporal cares for a hermitage, whence he emerged to be Pope, as Felix V. He filled the Papal chair for ten years, resigning in favour of Nicholas V.

Anaxagoras
b. Clazomenæ, Asia Minor, 500 B.C. d. Lampsacus, Asia Minor, 428 B.C.

The philosopher who paved the way for the atomic theory, had the courage to trace eclipses to natural laws, to divest the sun of its halo of deity, and correctly to analyse the origin of meteoric stones. His views conflicting with the superstitions of the age, he was driven forth to die in exile.

Andersen, Hans Christian
b. Odense, Denmark, April 2, 1805 d. Copenhagen, August 4, 1875

The divinity of the nurseries throughout the civilised world was the son of a poor shoemaker, and early in life had to work in a factory. The beauty of his voice induced him to attempt the stage, but for this he was declared too uncultured, and it was not until his early poems had attracted attention that he was enabled by sympathetic admirers to equip himself at a good school. His fairy stories are by this time classics.

Anderson, Alexander
b. Kirkconnel, Scotland, April 30, 1845

Bred to the work of the colliery, Mr. Anderson managed, while working on the pit-brow, to master French, Italian, and German, and to read the great poets in their own languages. Now the pit knows him no more; he has been appointed chief librarian of Edinburgh University. Of his many charming poems there is one—"Cuddle Doon"—of which Sir George Douglas says, "Scotland has made this as much her own as she has made Burns's songs." The poem is, indeed, a gem of music, humour, and tenderness.

Angelico, Fra
b. Vecchio, Italy, 1387. d. Rome, March, 1455

Fra Angelico is the name by which is best known Giovanni or Guidolino da Pietro, the great painter of religious subjects. He is specially famed for the spirituality and mystical charm of his saints and angels. Best examples of his work are at the Vatican, the Louvre, in the Uffizi, and at Orvieto.

Angelo, Michael. See Michaelangelo

Antony, Mark
b. 83 B.C. d. Alexandria, August, 30 B.C.

Related to Cæsar, and one of his closest adherents, Marcus Antonius induced the latter to make his (Antony's) expulsion from Rome the pretext for civil war, and himself led the left wing of Cæsar's army. At the death of Cæsar he played the rôle in which Shakespeare immortalised him. Forming, with Octavian and Lepidus, the second Triumvirate, he defeated Brutus and Cassius;

then summoned Cleopatra, Queen of Egypt, to meet him to settle an outstanding dispute. Captivated by her beauty and address, he followed her into Egypt. Called again to Rome, he was eventually defeated at Actium by Octavian, and fled to Egypt, where, deserted and alone, and deceived by a report of Cleopatra's death, he destroyed himself.

Apelles

b. Colophon, Asia Minor, 340 B.C. d. Cos, Asia Minor, 304 B.C.

Alexander the Great permitted only one man to make his statue, and only one man to paint his portrait. The painter was Apelles, the greatest artist of antiquity. He was most famed for his portraits, but his subject pictures were brilliant. He fell in love with Campaspe, a mistress of Alexander, who, it is told, surrendered her to the painter. From Campaspe Apelles drew his finest picture, "Venus rising from the Sea." Apelles had a varnish, the secret of which has been lost, whereby he added mellowness and beauty of tone to his work. He followed Alexander into Asia as far as Ephesus.

Aquila, Ponticus

b. Sinope, Asia Minor, 100 A.D.

Dates cannot with certainty be stated, but Aquila flourished about 130 A.D. He was skilled as a mathematician and architect, and was employed by his kinsman, the Emperor Hadrian, to assist in rebuilding Jerusalem. He gave the Greeks their first translation of the Old Testament, and was himself successively pagan, Christian, Jew.

Aquinas, Thomas

b. Calabria, Italy, 1225. d. Terracina, Italy, 1274.

Descended from the Counts of Aquino, Aquinas was born at his father's castle, Rocca-Secca, in which, upon his determining to enter the Dominican order against the parental wishes, he was imprisoned for two years. Escaping, he made his way to Albert Magnus, under whom he studied, until, long called "the dumb ox," he verified the saying of his master that "the voice of the ox shall one day fill the world." As a teacher he at once won fame. Having little Greek, and less Hebrew, he yet commanded the attention of the civilised world with his writings and with expositions of the Scriptures. Called now "the Angel of the Schools" and "the Eagle of Divines," he refused all Church preferments, remaining to the end simply the great theological scholar. At his death posthumous honours were heaped upon him. His "Summa Theologiæ" remains to-day substantially the standard authority of the Roman Catholic Church.

Archelaus

b. Athens, B.C., 480 (?).

The Ionic philosopher, scholar of Anaxagoras, who first demonstrated that the earth is round. This truth he deduced from observing that the sun rose and set at different times upon different parts of the earth. His fame was at its height in 450 B.C.

Archimedes

b. Syracuse, Sicily, 287 B.C. d. Syracuse, 212 B.C.

The "greatest mathematician and most inventive genius of antiquity"; first to establish the idea of specific gravity; perhaps, too, of the lever, in relation to which he uttered the well-known phrase, "Had I but a fulcrum whereon to rest, I could move the earth." The endless screw, the spiral pump for water, and innumerable engines of war which he was persuaded by his king to provide to withstand the assaults of the Romans—these, with great cranes, "burning mirrors," various hydraulic and compressed-air machines, were among his inventions. He preferred theory to practice, and despised his inventions. When the Romans at last broke through the defences of Syracuse, they found Archimedes bending over his diagrams drawn in the sand, and there killed him.

Ariosto, Ludovico

b. Reggio, Italy, September 8, 1474. d. Ferrara, Italy, June 6, 1533.

Educated as lawyer, soldier, scholar, Ariosto had with distinction discharged military duties, subjected a rebellious province, ruled as governor for three years, and conducted diplomatic missions before he devoted himself to writing. His works, which have long become classics, consist of satires, comedies, sonnets, songs, and lesser poems. But his great achievement is the grand, heroic poem, "Orlando Furioso," the completion of which occupied him sixteen years. It takes up Boiardo's unfinished "Orlando Innamorato," and with art which seems artless improvisation thrills and enchants by almost every page.

Aristarchus

b. Samos, Asia Minor, 280 B.C. d. Samos, 264 B.C.

A Greek astronomer, who, by demonstrating that the earth moves round the sun, anticipated the discovery of Copernicus. He measured the distances of the sun and moon from the earth; but, while he was geometrically correct, his lack of adequate instruments rendered his results inaccurate.

Aristides, The Just

b. Athens (?). d. Athens, 468 B.C.

The man whom Athens surnamed The Just was one of the ten generals at the Battle of Marathon, and, by inducing the others to surrender supreme control to Miltiades, enabled that general to win the day. Great in battle, and of noble character, he made Athens the ruling state in a maritime confederacy, and enabled every citizen, no matter what his rank or riches, to be eligible for the archonship. He died in honest poverty, and was buried by the state, which awarded his descendants pensions.

Aristophanes

b. Athens, 444 B.C. d. 380 B.C.

The greatest of Greek comic poets. The licence of the Athenian stage enabled him to expose abuses and evils inimical to the commonweal. Eleven plays—only a fifth of the number he wrote—are extant. Some are gross and coarse, reflecting not so much the mind of the man as his age. His work is characterised by infinite wit and fancy, and here and there power and beauty. "The Acharnians," "The Knights," "The Clouds," "The Wasps"—these, the four best known, alone suffice to secure his standing with the immortals.

Aristotle

b. Stageira, Macedonia, 384 B.C. d. Chalcis, Greece, 322 B.C.

One of the greatest philosophers of antiquity, Aristotle became, at the age of seventeen, the pupil of Plato, and for three years had for his own pupil Alexander the Great, who quitted the side of his master to go forth upon his career of conquest. Aristotle then opened his famous school in Athens, which he called the Lyceum, from its proximity to the temple of Apollo Lyceius. Here he treated of every subject which came within the range of ancient thought, and was rightly viewed, even down to Dante's day, as "the master of those that know." His influence and teachings remained the barrier between later eras and barbarism. His piety being impugned, remembering the fate of Socrates, he fled to Chalcis, in Eubœa, where he died, saying, as he left Athens, "I do not wish to see the Athenians sin twice against philosophy."

Arkwright, Sir Richard

b. Preston, Lancs, Dec. 23, 1732. d. Cromford, Derbyshire, Aug. 3, 1792.

The youngest of thirteen children, Arkwright began life as a dealer in human hair, which he dyed and sold for wigs. His education was so meagre that not until he was fifty had he time to master grammar and orthography. His invention of the spinning-machine revolutionised the cotton industry. The machine was made when he was so poor as to be in rags. He was thirty-six

when he set up his first machine in Nottingham, and had a hard battle to fight. A mob destroyed his factory at Chorley; masters and men were hostile to the new invention; protracted litigation greatly vexed him. In the end his triumph was pronounced. He originated factory labour; he created an industry representing untold wealth to his country. Not over-scrupulous in his dealings with other inventors, he was still a good master, and himself set an example of industry by working sixteen hours a day.

Armstrong, Lord

b. Newcastle-on-Tyne, Nov. 26, 1810. d. Rothbury, N'berland, Dec. 27, 1900.

The solicitor who revolutionised warfare was practising law while concerned with his first inventions. A colliery accident led to his investigating the generation of electricity from steam, and from this he worked on to the hydraulic crane, and all the hydraulic machinery for which his great works first became famous. At forty-nine he made his first big gun, and from that moment the history of heavy ordnance was changed. At first all his productions were for the British Government, but afterwards his business was extended to the Continent, and for field service and battleships his guns won world-wide reputation.

Arnold, Matthew

b. Laleham, Middlesex, December 24, 1822. d. Liverpool, April 15, 1888.

Poet, critic, educationist, author of the daintiest prose which conveyed hard-hitting truths, and of poetry which is pure music, Arnold has left a mark upon English literature and public life which will not soon be obliterated.

Arnold, Thomas

b. East Cowes, Isle of Wight, June 13, 1795. d. Rugby, June 12, 1842.

Father of the foregoing, Dr. Arnold, though a scholarly writer with a record of noble works, is best remembered for having revolutionised public school education in England during the fourteen years he was headmaster of Rugby.

Arrol, Sir William, Kt.

b. Houston, Renfrewshire, 1839.

The son of poor parents, Sir William Arrol began life as a cotton-piecer, was apprenticed at fourteen to a blacksmith, and with a capital of £85 began business on his own account. His energy and initiative broke down all obstacles to success, and at thirty he was building the new Tay Bridge, at a cost of three-quarters of a million. The Forth Bridge, and later the Tower Bridge, followed, and innumerable other great schemes. For these enterprises he had to invent practically all his own tools, and by so doing created a new and remunerative industry.

Ashmole, Elias

b. Lichfield, Staffordshire, May, 1617. d. London, May 18, 1692.

A man who, though he hung spiders about his neck for ague, and dabbled in alchemy, will, as his epitaph says, be remembered as long as his museum endures. This he got for the most part from his friend John Tradescant. He gave all, with the residue of the library which he had been thirty years collecting, to Oxford University. Fire had greatly damaged his library, but the Ashmolean museum is still famous for its manuscripts.

Athanasius, St.

b. Alexandria, Egypt. 29 A.D. d. Alexandria. 373 A.D.

The greatest of the Greek Fathers, of whom Gibbon says, "His immortal name will never be separated from the Catholic doctrine of the Trinity, to whose defence he consecrated every moment and every faculty of his being." He was the great champion of the Church against Paganism and Arian heresy, and spent twenty years of his life in exile—six in the desert, a hunted fugitive. Athanasius, who introduced monasticism into Western Europe, is not the author of the Athanasian Creed, of which nothing was heard until long after his time.

Attila

b. 406 A.D. d. Pannonia, Europe, 453 A.D.

"The Scourge of God," descended from the ancient Huns who dwelt on the confines of China. Putting his brother Bleda to death, he became master of the then vast kingdoms of Germany and Scythia, his dominions extending from the Rhine to the frontiers of China. He invaded Rome, and compelled Theodosius to pay tribute. This Marcian, the latter's successor, refused to continue, and in a great battle Attila was defeated. He again invaded Italy, and fugitives, flying before him, founded what was to become the famous Venetian Republic. Attila, whose boast was that "grass never grows again where my horse has once trodden," left an empire which his sons, by civil wars, rapidly destroyed.

Augustine, St.

b. Tagaste, N. Africa, Nov. 12, 354 A.D. d. Hippo, N. Africa, Aug. 28, 430 A.D.

The father of Augustine was a Pagan until late in life, and Augustine himself lived a life of licentiousness upon first going to Carthage. Cicero and Plato called him to nobler aims, and it was from the study of philosophy that he turned to Christianity, being baptised when thirty-four. His immortal autobiographical "Confessions" were written when he was forty-four. To heresy he proved a redoubtable foe, and for centuries after his writings ruled the Christian Church. He died while the Vandals were besieging Hippo, of which he was at the time bishop.

Augustus, Cæsar

b. 63 B.C. d. Nola, Italy, 14 A.D.

The man who found Rome built of brick, and left it built of marble, was the grand-nephew of Julius Cæsar, to whose will, after a struggle with Mark Antony, he gave effect. He parted the Roman world with Antony and Lepidus, who took – the former Gaul, the latter Spain; while Augustus himself had Africa, Sardinia, and Sicily. By his victory at Actium over the forces of Cleopatra, after which she and Antony committed suicide, he became the enlightened and noble master of the Roman world. His name, really Caius Julius Cæsar Octavianus, was changed to Augustus, meaning sacred or venerable, and it exists to-day in the name of our month of August, which formerly was Sextilis, then the sixth month of the Roman year.

Austen, Jane

b. Steventon, Hampshire, Dec. 16, 1775. d. Winchester, July 18, 1817

The heroine of an enthusiastic eulogy by Macaulay was a daughter of the rectory, studied French and Italian, and was conversant with Richardson, Johnson, Crabbe, Cowper, and, at a later period, with Scott. She introduced the novel of domestic life. Four of her best-known novels were published anonymously during her life; the others were not given to the world until the year following her death. "Sense and Sensibility" and "Pride and Prejudice" were written before she was twenty-two.

Bach, John Sebastian

b. Eisenach, Germany, March 21, 1685. d. Leipzig, July 28, 1750

A member of a family of musicians, Bach was entirely self-taught. He never had instruction in instrumentation, nor in the theory of music. He created his own style. "Every room in which Bach is sung is transformed into a church," said Mendelssohn. Blindness fell upon him in his latter days, and the operation attempted for his relief brought about his death.

Bacon, Francis

b. London, January 22, 1561. d London, April 9, 1626.

"The wisest, brightest, meanest of mankind," as Pope termed him, died Lord Verulam and Viscount St. Albans. He never was Lord Bacon, the name by which he is commonly called. His career as a public man was marred by servility and treachery. He fawned upon the powerful, to

turn without mercy upon them—notably, in the case of the Earl of Exeter—when his ends had been served. Successively filling all the offices of State leading to the Lord Chancellorship, he fell from the latter office, convicted of the grossest corruption, was sentenced to imprisonment in the Tower, fined £40,000, and banished the Court and Parliament. The sentence was remitted, but he continued in retirement. His literary labours entitle him to be styled the "father of English learning." While he was ignorant of discoveries of his contemporaries, and cherished many superstitions, he gave an impetus to English learning such as no other man had done.

Bacon, Roger
b. Ilchester, Somerset, 1214. d. Oxford, 1294.

The "wonderful doctor," as he was called, became a monk of the Franciscan order, which prevented his publishing his writings. He dabbled in alchemy, but made notable discoveries, gunpowder and the magnifying-glass among them. He is famous as being the pioneer of modern scientific inquiry. Persecuted and hindered to an unparalleled degree, he yet contrived to leave a striking record of work accomplished.

Baker, Sir Samuel
b. London, June 8, 1821. d. Newton Abbot, Devon, December 30, 1893.

A daring traveller, who, with his wife, essayed the exploration of the Nile sources, and, in company with Speke and Grant, discovered the great lake to which he gave the name Albert Nyanza. He helped to suppress slavery in Egypt, explored Cyprus, extended his travels east and west, and wrote one or two valuable books.

Balfe, Michael William
b. Dublin, May 15, 1808. d. Rowley Abbey, Herts, October 20, 1870.

An Irish composer, whose memory is dear to multitudes who have been charmed with his melodious operas and other compositions.

Baliol, John de
b. Barnard Castle, Durham. d. 1269

One of the wealthiest barons of his time, he founded Balliol College, Oxford. His third son, John de Baliol (1249-1315), became King of Scotland, but was taken prisoner by Edward. His son Edward recovered the crown after a bloody battle, in which the Regent Mar was slain, but died in 1367. With him the line of Baliol ended.

Balzac, Honoré de
b. Tours, France, May 20, 1799. d. Paris, August 18 1850.

An indefatigable French author, who in twenty years wrote eighty-five novels, several of them masterpieces. His "Comédie Humaine," in which every phase of life and character was to be treated, proved too vast an undertaking, but in it is some of his finest work.

Baring, Sir Francis
b. Larkbear, Devonshire, 1740. d. Lee, Kent, 1810.

The son of an immigrant German, who, along with his brother John, founded the financial house of Baring Bros. Lord Cromer and Lord Northbrook descend from the same stock.

Bayard, Pierre du Terrail
b. Grenoble, France, 1476. d. Italy, 1524.

The last of the great heroes of chivalry, he was, at the age of eighteen, the most accomplished knight of his time. His feats in war and council were equally notable. He was for thirty years regarded throughout Europe as the mirror of chivalry, and his name still serves as a synonym for noble, unselfish, and heroic deeds.

Becket, Thomas
b. London, 1118. d. Canterbury, December 29, 1170.

Of Norman parentage, Becket showed extraordinary ability as a young man, and, securing the patronage of the Archbishop of Canterbury, was employed to win the Papal recognition of the Plantagenet dynasty on the English throne. From 1155 Becket was Chancellor—ostentatious, unscrupulous, and worldly. Then, in 1162, the Archbishopric of Canterbury was forced upon him by Henry II. The office wrought a miracle in his life. The worldling gave place to the stern ascetic and great champion of the Church. He asserted her rights, and boldly denied the Royal prerogative, but was forced to fly to France, and remain in exile for six out of his eight years' primacy. The struggle ended in his assassination at the altar of Canterbury Cathedral by knights acting upon the exclamation of the King: "Of the cowards that eat my bread, will none rid me of this turbulent priest?"

Bede, The Venerable
b. Monkwearmouth, Durham, 673. d. Jarrow, Durham, 735

The father of English history was educated at a monastery between Monkwearmouth and Jarrow. There he spent all his days diligently compiling his history, his scientific and theological treatises, and teaching and expounding with such distinction as to make Northumbria the literary centre of Western Europe.

Beethoven, Ludwig Von
b. Bonn, Germany, December 16, 1770. d. Vienna, March 26, 1827.

Beethoven, like Bach, was one of a musical family, and at fifteen was Court assistant-organist, having already appeared as a juvenile pianist. By the time he had attained his twenty-third year he was noted as the most brilliant extempore player of his day. He now went to Vienna to study, and there remained for the rest of his life. His compositions comprise all forms of music—vocal and instrumental from the sonata to the symphony, from the simple song to the opera and oratorio. Upon his works the modern school of instrumental music has been founded.

Bell, Sir Charles
b. Edinburgh, November, 1774. d. Worcester, April 28, 1842.

He made the greatest discovery in physiology from the time of Harvey to his own day—the distinction between the sensory and motor nerves. He held many high positions in his profession, and took charge of the wounded after the battles of Corunna and Waterloo.

Bell, Alexander Graham
b. Edinburgh, March 3, 1847.

The inventor of the telephone is the son of a famous father, Alexander Melville Bell, author of the system of "Visible Speech." It was while teaching this system that Bell the younger invented the telephone. He deposited his drawing and specifications the same day on which Mr. Elisha Gray filed particulars of his telephone. Edison's differed somewhat from both. Mr. Bell has since then invented the photophone, which transmits sound by variations in a beam of light; the graphophone, and similar instruments.

Bell, Henry
b. Torphichen, Linlithgow, 1767. d. Helensburgh, Dumbarton, Nov. 14, 1830.

The father of European steam navigation was first a wheelwright, then a ship modeller, and next worked under Rennie, the famous engineer. He helped Fulton to make his steamboat; and himself, after many years' patient toil, produced his Comet, a boat of twenty-five tons, propelled by an engine of 3 h.-p. at a speed of seven miles an hour.

Belzoni, Giovanni Battista
b. Padua, Italy, 1778. d. Benin, W. Africa, December 3, 1823.

First a monk, he was driven, by the invasion of Rome by the French, to England, where he earned a livelihood in the streets as a "strong man." Starting his career proper, he explored Egypt, and invented a hydraulic machine for raising the waters of the Nile. He removed and sent to England the colossal statue of "Young Memnon," and was the first to enter the second great pyramid of Gizeh. He was the father of modern Egyptian research.

Bentham, Jeremy
b. London, February 15, 1748. d. London, June 6, 1832.

The son of an attorney, he devoted his life to ethics and jurisprudence, and, in the words of Mill, found the philosophy of law a chaos, and left it a science. He advocated universal suffrage, annual Parliaments, the ballot, and payment of members. To many of his ideals effect has already been given by Parliament. His skeleton, dressed in the clothes he wore, is preserved at University College, London.

Becquerel, Alexander Edmond
b. Paris, March 24, 1820. d. Paris, May 13, 1891.

The son of Antoine Cæsar Becquerel, who was noted as a physicist, he made important investigations in relation to light, and discovered the rays to which his name is given.

Bergmann, Torbern Olof
b. Sweden, 1735. d. Upsala, Sweden, 1784.

Although a victim of poor health, he showed extraordinary assiduity in problems in botany, geology, and mineralogy. His theory of elective or chemical affinities has had a great influence on the later developments of chemistry.

Berlioz, Hector
b. Isère, France, December 11, 1803. d. Paris, March 8, 1869.

A composer whose genius was often akin to madness, he had for long to depend for a livehood upon musical criticism instead of musical composition. In the end his triumph was complete, his "Faust," "Romeo and Juliet," "Beatrice and Benedict," "Messe des Morts," and "Te Deum" sufficing to make for him a reputation which time enhances.

Berthelot, Pierre Eugène Marcellin
b. Paris, October 29, 1827.

The father of synthetic chemistry, the chemistry which builds up new forms, fled from a priestly seminary to devote himself to science. Other scientists had analysed and broken up matter; he put together the fragments, invented explosives and chemical and commercial products innumerable. To-day the school which has grown up in his train enumerates and defines fifty thousand distinct compounds. He has been Minister for Education and for Foreign Affairs of France.

Bertillon, Alphonse
b. Paris, 1853

A French police officer, who re-equipped the detective forces of the world by inventing a means of identifying criminals by measurements.

Bessemer, Sir Henry
b. Charlton, Herefordshire, January 19, 1813. d. London, March 15, 1898.

Many inventions, some of which never yielded him any profit, stand to the credit of Bessemer, but his process for the cheapening of steel is his chief claim to fame. He discovered that by forcing a blast of air through the molten metal he could decarbonise it, and convert cast iron into steel. His discovery did not at first yield the desired results, and he was discredited. Years of disappointment followed, but he persevered until his invention was finally perfected, and, by producing steel from his own works at £20 a ton less than the trade generally, rehabilitated himself. He made a vast fortune, and revolutionised the steel industry of the entire world.

Bichat, Marie François Xavier
b. Thoirette, France, 1771. d. Paris, July 22, 1802.

A happy accident brought his abilities to the notice of Desault, who forthwith adopted him as his son. Profiting by the knowledge thus early placed at his disposal, Bichat became the greatest anatomist and physiologist of his age. He was the first to reduce the complex structure of the organs to their elements, and to simplify the whole science.

Bismarck, Prince Otto Edouard Leopold
b. Schönhausen, Germany, April 1, 1815. d. Friedrichsruh, July 30, 1898.

Destined to complete the work of Frederick the Great, Bismarck was first opposed to all popular reform, and, though he was afterwards to give universal suffrage, he voted against a constitution for Prussia. Experience as Prussian representative at the Frankfort Diet, and as Ambassador to Russia and France, modified his views, and it was a more liberal Bismarck who was called to the assistance of the despairing King of Prussia. He employed Austria to help in wresting Schleswig-Holstein from Denmark, then turned on Austria and crushed her, making Prussia supreme in Germany. France had next to be faced, and a four years' preparation culminated in Bismarck's falsifying a telegram to misrepresent a meeting between the King and French Ambassador. The Franco-Prussian War followed. Here, again, German arms were triumphant; and while the Second Empire was being crushed, Bismarck confederated the German States into the German Empire, with the King of Prussia as German Emperor. Loaded with honours and rewards, Bismarck retained office until 1890, when he was dismissed by William II.

Black, Adam
b. Edinburgh, February 20, 1784. d. Edinburgh, January 24, 1874.

A worthy publisher, who originated the "Encyclopædia Britannica," and became proprietor of the "Edinburgh Review" and of the copyright of Scott's novels.

Black, Joseph
b. Bordeaux, France, 1728. d. Edinburgh, November 26, 1799.

The founder of modern chemistry was the son of a wine-merchant. He exploded the theory that the causticity of lime and the alkalis is due to their absorption of the so-called phlogiston, and traced it to carbonic acid. His discovery as to latent heat was of still greater importance to subsequent investigators.

Blake, Robert, Admiral
b. Bridgwater, Somerset, August, 1598 d. Plymouth, August, 1657.

Was a member of the Long Parliament, and in the Civil War gave the turning-point to the issue. At sea he completed the discomfiture of the Royalists; then, turning his attention to the Dutch fleet, whose admirals in those days were giants, gave us the supremacy of the seas.

Blucher, Gebhard Lebrecht von
b. Rostock, Germany, 1742. d. Kirblowitz, Germany, September 12, 1819.

A soldier from boyhood, he considered himself neglected by Frederick the Great, and took to farming for fifteen prosperous years. Recalled by Frederick William II., he fought in innumerable battles, Jena, where he was a subordinate, among them. At Leipzig he had a great share in defeating the French, and at Waterloo appeared just in time to complete the overthrow of Napoleon, by whom he had only a few hours previously been defeated in the terrible battle of Ligny.

Boadicea
d. 62 A.D.

Queen of the Iceni, a British people living in Eastern England, Boadicea was robbed, at the death of her husband, King Prasutagus, of all her possessions, herself publicly whipped, and her daughters exposed to the brutalities of the Roman soldiers. She raised the Britons, captured Colchester, London, and St. Albans, and put to death, according to Tacitus, 70,000 Romans. The island would have been lost to Rome had not Suetonius Paulinus hastened from Anglesea with 10,000 disciplined soldiers. Boadicea's force of over 200,000 was powerless against the Roman legions, and suffered a terrible defeat. Thereupon Boadicea poisoned herself.

Boccaccio, Giovanni
b. Certaldo, Italy, 1313. d. Certaldo, December 21, 1375.

The "father of Italian prose" was the natural son of a merchant, and intended successively for commerce and canon law. The years which he devoted to those subjects were wasted, and much of his time in later life was taken up with diplomatic missions. The rise of Italian prose began

with his writings, and his influence is to be traced throughout the subsequent literature of Europe—in our own not least. Poets and novelists alike, from Shakespeare to Tennyson and George Eliot, have turned to him for inspiration. Licentiousness characterises some of his works, but others comprehend the loftiest ideals expressed in the noblest language.

Bodley, Sir Thomas
b. Exeter, March 2, 1545. d. London, January 28, 1613.

After having acted as Ambassador for several years, he devoted his talents and resources to re-establishing the library which Humphrey, Duke of Gloucester, had bequeathed to Oxford. This he so enriched with MSS. and books from all parts of Europe as to make it one of the finest in the world. It is called the Bodleian, in his honour.

Boerhaave, Hermann
b. Voorhout, Holland, 1668. Leyden, Holland, September 23, 1738.

The greatest physician and chemist of his time taught practically the whole of Europe. Peter the Great sat at his feet, and letters came to him from China seeking his advice. His works were translated into every European language, and even into Arabic.

Bolivar, Simon
b. Caracas, Venezuela, July 24, 1783. d. San Pedro, Colombia, Dec. 17, 1830.

The liberator of South America from the yoke of Spain saw the close of the French Revolution, and carried the revolutionary spirit with him back to Venezuela. After a protracted struggle with the Spaniards, he finally drove them out, and formed Colombia, Venezuela, New Granada, and Ecuador into a great Republic. Over this he ruled, while he was dictator of Peru. Bolivia, which was formerly Upper Peru, still commemorates him. His great Republic proved more than he could control, and he surrendered his office a few months before he died. He was the greatest patriot South America has known.

Bonaparte. See Napoleon

Borrow, George Henry
b. East Dereham, Norfolk, July 5, 1803. d. Oulton, Suffolk, July 26, 1881.

Leading a wandering life as a child with his father, who was a captain of Militia and moved with his regiment, Borrow, who acquired tongues and dialects with extraordinary facility, early mastered Irish, Danish, Welsh, French, German, Greek, and even Romany, the language of the gipsies, whose life and manners he has so fascinatingly described. His subsequent wanderings are related in his delightful "Lavengro," and his experiences as a representative of the Bible Society in "The Bible in Spain." At thirty-seven he married a wealthy widow, but was a rambler till late in life. Among his fourteen works are those which will last as long as the language.

Boswell, James
b. Edinburgh, October 18, 1740. d. London, May 19, 1795.

The man who immortalised Samuel Johnson and himself at the same time was a Scottish lawyer, son of Lord Auchinleck, a judge of the Court of Session. In his youth he travelled, and met Rousseau, Voltaire, and Paoli, the Corsican patriot. Coming to London, he met Johnson, which crowned his happiness. His "Life of Johnson" appeared seven years after his hero's death, and was an instant success. It was acclaimed the greatest biography in the language, and such it remains. Boswell gave way to intemperance in his later years, and died miserably. His "Life" was the one meritorious performance of his career, and that was meritorious indeed.

Botticelli, Sandro
b. Florence, Italy, 1447. d. Rome, May, 17, 1510.

Alexander Filipeppi was the name of this great Florentine artist, who, however, adopted the title of the goldsmith to whom his father apprenticed him. His training here in goldwork and jewellery was valuable to him in his painting. He studied under Fra Lippo Lippi, whose work he excelled. Botticelli's paintings, both in classical and religious veins, are marked by infinite delicacy, beauty, and care. Glorious examples are to be seen in the National Gallery. He was among the first engravers. Although he made large sums of money, he died in poverty.

Bougainville, Louis Antoine de
b. Paris, November 11, 1729. d. Paris, August 31, 1814.

A man who might have gained reputation as mathematician or philosopher, Bougainville's fame rests upon his having been the first son of France to circumnavigate the world. This he accomplished, 1766-69, in a frigate, accompanied by a transport, and lost only seven men out of a crew of two hundred. In his closing days he was honoured by Napoleon.

Bouguer, Pierre
b. Croisic, France, February, 10, 1698. d. Paris, August 15, 1758.

Mathematician, hydrographer, and geometrician, he devoted ten years of his life to measuring a degree of meridian near the Equator. He made important discoveries concerning the expansion and contraction of metals, the refraction and density of the atmosphere, the reciprocation of the pendulum, and the mode of measuring the force of light. To Bouguer we owe the foundation of photometry and the invention of the heliometer.

Boulton, Matthew
b. Birmingham, September 14, 1728. d. Birmingham, August 17, 1809.

He was the son of a Birmingham silver stamper and piercer, and improved the manufacture of art work in metal, pottery, etc. He converted a barren heath at Soho, Birmingham, into a great industrial establishment, and induced Watt to join him. They produced the steam-engines for which they were famous. In addition, they enjoyed unique reputation for the manufacture of coins. Patient industry, as well as genius, conduced to their success. Their manufacture of steam-engines was profitless for the first eighteen years of their association.

Bourgelat, Claude
b. Lyons, France, 1712. d. Lyons, 1799.

The father of veterinary science was intended for the law, but, disgusted at having gained a verdict in which his client was, to his knowledge, in the wrong, he joined a cavalry regiment, made a study of horses, and opened the first veterinary school in Europe.

Bourne, Hugh
b. Fordhays, Staffs, April 3, 1772. d. Bemersley, Staffs, October 11, 1852.

Dismissed from the Wesleyan body, of which he was a member, he established a little community, which has since grown to importance, under the name of Primitive Methodists. He worked for the greater part of his life as a carpenter, but carried his message throughout the United Kingdom and to the United States.

Bowring, Sir John
b. Exeter, October 17, 1792. d. Exeter, November 23, 1872.

We owe to Bowring much of our knowledge of the folklore of other nations. He was one of the greatest linguists the world has seen; was master of forty languages, and declared that he knew two hundred, and could speak one half that number. While he was supreme naval and military head at Hong Kong, his action in ordering fire to be opened on the Canton forts caused the "Arrow" war with China.

Boyle, Robert
b. Lismore Castle, Ireland, January 25, 1627. d. London, December 30, 1691.

The true precursor of the modern chemist, one of the founders of the Royal Society, and one of the greatest natural philosophers of his age, was the seventh son of the great Earl of Cork. He made experiments with an air-pump, which he improved, and important discoveries as to the properties of air and the propagation of sound. A

devout Christian, he caused the Bible to be translated into several foreign languages at his expense.

Bradley, James
b. Sherborne, Dorset, March, 1693. d. Chalford, Glos., July 13, 1762.

Though he took Orders, and was presented to two small sinecure livings, he did not give up his studies, his whole life being devoted to science. Six years after being appointed Savilian Professor of Astronomy, at Oxford, he made known his discovery of the aberration of light; following this by explaining the nutation of the earth's axis, whose inclination towards the ecliptic, he was able to show, is constant.

Brahe, Tycho
b. Knudstorp, Sweden, Dec. 14, 1546. d. Prague, Austria, Oct. 24, 1601.

Brahe studied astronomy when he should have been learning law, and made himself famous in a direction not desired by his parents. He did much to advance the science to which he was devoted, though his theory a modification of the Ptolemaic, and rejection of the Copernican was, of course, erroneous. Kepler was his pupil, and owed much to him.

Braidwood, Thomas
d. Edinburgh, 1715. d. London, October 24, 1806.

Braidwood was the first man in England to systematically teach the deaf and dumb. His school, opened in Edinburgh, was afterwards transferred to London, and its operations extended by his daughter-in-law, Isabella Braidwood, to Birmingham.

Braille, Louis
b. Coupvray, France, January, 1809. d. Paris, 1852.

Rendered blind by an accident when three years of age, Braille devoted his life to perfecting the beautiful system by which the sightless are enabled to read and write in relief.

Bramah, Joseph
b. Stainborough, Yorkshire, April 13, 1748 d. London, December 9, 1814.

Lame from an accident with which he met when sixteen years of age, he was compelled to quit work in the fields for cabinet-making, whence he passed to his true vocation—engineering. He invented many useful machines among them the hydraulic pump, sanitary apparatus, printing machinery for banknotes, fire-engines, and a famous safety lock. His boilers for steam-engines enjoyed a high reputation, and he was one of the first to suggest the screw propeller for steamships.

Bramante, d'Urbino (Lazarus)
b. Urbino, Italy, July, 1444. d. Rome, 1514.

Bramante relinquished painting to devote himself wholly to architecture, in which he had Raphael as a student. He was commissioned by Pope Julius II. to undertake the first part of one of the greatest enterprises in history the rebuilding of St. Peter's, Rome. He died before his work could be completed. Subsequently his designs were departed from by other architects; but expert opinion holds that had his plan been followed, the effect would have been more grand and impressive.

Brassey, Thomas
b. Barton, Cheshire, November 7, 1805. d. St. Leonards, December 8, 1870.

A man of scanty schooling, with no command of foreign languages, Brassey, who was the son of a small landowner, became head of the greatest industrial enterprises ever committed to the care of a single man. He built many railways, docks, and harbours in England; while, at the same time, his operations embraced the construction of railways in almost every country in Europe, India, Australia, Canada, and South America. He had an army of 75,000 workmen, whose wages represented from £15,000 to £20,000 every Saturday. He amassed enormous wealth, and made the fortunes of many of his subordinates. A man of simple, noble nature, he was in all his business relations scrupulously honest and just.

Breakspear, Nicholas (Pope Adrian IV.)
b. Abbot's Langley, Herts, 1100. d. Anagni, Italy, September 1, 1159.

The only Englishman to fill the Papal chair was the son of a poor clerk who turned monk, and left his son destitute. Nicholas used daily to attend the monastery at St. Albans; then, making his way to France, was received in a menial capacity into the house of the canons of St. Rufus, near Valence. Here he became prior and abbot; was then sent by the Pope to found a new archiepiscopal see for Norway, and at the death of Anastasius, in 1154, was himself elected Pope. He it was who gave Ireland to Henry II., that he might civilise the Irish, and bring them into the Roman Church. His reign was one long struggle for the temporal supremacy of the Papacy over contemporary sovereigns.

Bridgewater, Francis Egerton, Duke of
b. May 21, 1736 d. London, March 8, 1803

The "father of inland navigation in England" was so dull of intellect as a boy that his exclusion from the dukedom was seriously proposed. He built the first canal in this country dependent wholly upon an artificial waterway. It ran from Worsley to Manchester, and was forty-two miles in length. The canal uniting Manchester and Liverpool followed, and was so costly that at times its projector was glad to borrow a £5 note from his tenants. He spent in all nearly a quarter of a million on his canals, but before his death benefited from them to the extent of £80,000 a year.

Brindley, James
b. Chapel-en-le-Frith, Derbyshire, 1716 d. Turnhurst, Staffs, Sept. 30, 1772.

The unlettered son of a ne'er-do-well, built the Bridgewater and other canals, the first of their kind in England. He was a genius who worked for a guinea a week. The schemes for the canals he fashioned in his head; he could never draw or write. Troubled by a problem, he would retire to bed and think it over, when all would come right.

Broadwood, John
b. Cockburnspath, Scotland, 1732 d. London, 1812

Having walked from Scotland to London to seek to make his fortune as a cabinet-maker, Broadwood took service with Burkhardt Tschudi, a Swiss harpsichord-maker. He married the daughter of the latter, and, becoming possessor of the business, won fame throughout Europe for his pianos.

Brontë, Charlotte
b. Thornton, Yorks, April 21, 1816. d. Haworth, Yorks, March 31, 1855.

Charlotte was the eldest of a family of four, of whom her brother, Patrick Branwell Brontë, a profligate, with some touch of the family genius, died of consumption. Her father was an eccentric, selfish clergyman. Her sisters Anne and Emily Jane like herself, were delicate, but shared her talent. They published jointly a little book of poems, but had to seek livelihood as governesses. This failing, Emily wrote her famous "Wuthering Heights," and Charlotte, having had the "Professor" rejected, commenced at once "Jane Eyre," which met with instant success. Anne produced "Agnes Grey." Charlotte's brother and two sisters died within a short time of each other, and she was left to attend to her father, and continue her literary work, uncheered. She married, in 1854, the Rev. A. B. Nicholls, who had been her father's curate, but died in the following year. The story of the three sisters is one of the saddest in literature. Genius was never nurtured in more dispiriting, uncongenial conditions.

Brown, John
b. Torrington, Connecticut, May 9, 1800. d. Charlestown, Virginia, Dec. 2, 1859

The famous agitator for the abolition of slavery in America was of pilgrim stock, and lived as tanner, land-surveyor, and farmer until he devoted himself to anti-slavery propaganda. It was rough work, and bloody. Brown had five pro-slavery men shot, and, after organising an asylum in the

mountains of Virginia for runaway slaves, attacked the Harper's Ferry armoury in Virginia. He was taken, tried, and hanged, but his life was not given in vain. His rough efforts aided enormously in the crusade against slavery, while his death was an even more powerful factor in the scale.

Browning, Robert

b. London, May 7, 1812. d. Venice, December 12, 1889.

Endowed with many gifts, with some talent for drawing, and a taste for musical composition, Browning could rhyme almost as soon as he could talk. He had written a little volume of poems before he was twelve, and finished his dramatic poem "Pauline" by the time he was nineteen. The best known of his shorter poems were written before he was five-and-thirty. After his marriage to Elizabeth Barratt herself the most imaginative poetess that has yet appeared in England, perhaps in Europe he settled in Florence, but returned, a widower, to London to publish his masterpiece, "The Ring and the Book." He died in Venice, but is buried in Poets' Corner, Westminster Abbey. Obscure and difficult as Browning often is, he stands high among the poets of all time. It has been well said that whereas Wordsworth would lead the soul through nature to rest, it is through the spiritual struggles of the soul itself that Browning reveals the divine touch that discloses the true end of living and thinking.

Bruce, James

b. Kinnaird, Stirlingshire, December 14, 1730. d. Kinnaird, April 27, 1794.

Intended first for the Church, next for the law, Bruce was for a time a wine merchant before the fascination of the East inspired by his knowledge of Arabic, led to his taking the Consulate at Algiers. Seeking the source of the Nile, he discovered that of the Blue Nile, a matter in which, however, he had been anticipated. His travels and adventures in Abyssinia and Egypt, extending over six years, were set forth, upon his return home, in five volumes. So remarkable were his stories that he was generally discredited, though subsequent travel has handsomely vindicated him. In stature a giant, and a man of fine courage and delightful nature, he has been described as the poet, and his work the epic, of African travel.

Brunel, Isambard Kingdom

b. Portsmouth, April 25, 1806. d. London, September 15, 1859.

The only son of Sir Marc Isambard Brunel, he inherited much of his father's genius, and heroically assisted in the building of the Thames Tunnel, a labour of almost unparalleled difficulty and trial. In business for himself, he built many notable bridges, and laid the Great Western railway-track. His was the first steamship the Great Western regularly engaged in traffic between Great Britain and America. Afterwards he built the Great Eastern, the leviathan of her time, which was useful in laying submarine cables. Like his father, he was a man of lovable character and an unselfish, unswerving friend.

Brunel, Sir Marc Isambard

b. Hacqueville, France, April 24, 1769. d. London, December 12, 1849.

One of the most versatile geniuses of any age, Brunel the elder spent seven years of his youth at sea, then was driven by the French Revolution to America, where he took up civil engineering, and became the chief engineer of New York. Coming to England, when thirty years of age, to offer an invention to the Admiralty, he married an English lady, and made his home here. His invention was a machine for making ships' blocks, which saved the Government £24,000 a year. Afterwards he executed important works at the arsenals and dockyards, built great sawmills, and invented machinery for boots, printing processes, writing and drawing-machines, a knitting-machine, and a marine engine. In spite of his genius and industry, he was for months a prisoner for debt. His crowning achievement was the building of the Thames Tunnel, for the purpose of which he invented his famous shield. Nearly twenty years elapsed before the work was completed, but he lived to see the triumphant end of his labours.

Bruno, St.

b. Cologne, 1030. d. Calabria, Italy, October 6, 1101.

As superintendent of all the schools of the Diocese of Rheims, he had many distinguished pupils, among them the future Pope Urban II. He is chiefly notable, however, as the founder of the famous Carthusian Order, which he established upon withdrawing to the desert of Chartreuse.

Brunton, William

b. Dalkeith, Scotland, May 6, 1777. d. Camborne, Cornwall, Oct. 30, 1851.

The son of a watch and clockmaker, he worked first at Arkwright's mills, then under Boulton and Watt at Birmingham, where he became a foreman. When over sixty, he lost all his money through a disastrous speculation in business, but recouped himself. His inventions comprised many useful, and some fantastic, ones. Of the latter there was a walking-machine, called the steam-horse, which for a year carried loads up a steep gradient, but then exploded, killing thirteen people. His work in connection with steam navigation, however, was of primary importance. Some of the original engines used on the Humber and Mersey were of his design; while the Sir Francis Drake, the first steamer which ever towed a war vessel, was fitted out by himself.

Buddha

b. Kapilavastu, India, 480 B.C. d. Kusinagara, India, 400 B.C.

Only approximate dates can be given. His real name was Siddhartha, and he was the son of Siddhartha Gautama, raja of the Sakya clan, whose home was near Oudh. When nineteen he married his cousin, a princess, but renounced luxury and family joys to go for six years into the wilderness and study under learned Brahmans, practising severe penances the while. It dawned upon him one day that salvation was not to be sought in isolation, but in self-conquest and universal loving kindness. That instant he became consciously Buddha, which means "enlightened." He returned to his family, began his teaching at Benares, and travelled far and near, inculcating his doctrines. His converts were numerous, and to-day his religion is the faith of 500,000,000 people, half as many again as the whole of professing Christians.

Buffon, George Louis, Comte de

b. Montbard, France, September 7, 1707. d. Paris, April 15, 1788.

The son of a wealthy lawyer, Buffon devoted his whole life to the study of natural history, his great work upon which, though perhaps over-praised by his contemporaries, remains a wonderful achievement, considering the condition of scientific knowledge in the eighteenth century. He was a forerunner of Darwin, in that he takes a distinct place in the history of the doctrine of evolution.

Bunsen, Robert Wilhelm

b. Gottingen, Germany, March 31, 1811. d. Gottingen, August 16, 1899.

The co-originator, with Kirchhoff, of spectrum analysis, which opened a new world to chemists and astronomers, was one of the most painstaking men that ever lived. Although he destroyed the sight of one eye, and nearly poisoned himself by his experiments, he succeeded, by applying science to commerce, in effecting great reforms in the manufacture of iron, in inventing the burner which bears his name, the charcoal pile and the magnesium light, and many other valuable processes.

Bunyan, John

b. Elstow, Bedfordshire, November, 1628. d. London, August 31, 1688.

The son of a tinker, and himself trained to the same trade, Bunyan had but little schooling; and his experience as a soldier, when he was drafted into the Parliamentary Army, does not seem to have improved him. At the time of his marriage he was "the ungodliest fellow for swearing" his

friends had ever heard. His wife brought him for dowry two pious books; and the study of these, assisted by her own influence, effected his ultimate reformation. He became a powerful preacher. Nonconformist ministers of the Gospel coming under the official ban, he was cast into prison. He remained for some twelve years in the Bedford County Gaol, where he wrote several works. His release at last secured, he resumed his preaching, but was cast again into gaol, remaining a prisoner for six months. It was during this second incarceration that he wrote the first part of his deathless "Pilgrim's Progress." This, with "Grace Abounding" and "The Holy War," will live as long as religion has a literature. It has been translated into practically every known language, and fault will not be found with the dictum of Macaulay: "There is no book in our language on which we would so readily stake the fame of the old unpolluted English language; no book which shows so well how rich that language is in its own proper wealth, and how little it has been improved by all it has borrowed."

Burdett-Coutts, Angela Georgina, Baroness
b. London, April 21, 1814

The daughter of Sir Francis Burdett, M.P., she succeeded, at twenty-one, to the vast fortune of her grandfather, Thomas Coutts, through his widow, who had been an actress, but died Duchess of St. Albans. Made a baroness in her own right, she devoted her life to noble works. She built churches, founded three Colonial bishoprics, instituted official inspection of schools, equipped topographical surveys of the Holy Land, helped to establish Rajah Brooke in Sarawak, assisted emigration and war funds, formed many charitable institutions, built Clare Market, and model lodging-houses. Her career of goodness is almost without parallel in the history of Englishwomen.

Burke, Edmund
b. Dublin, January 12, 1729 d. Beaconsfield, Bucks, July 8, 1797.

His father was a Protestant lawyer, his mother a Roman Catholic, and his first schoolmaster a Quaker -a combination of factors which early taught him the lesson of religious toleration. Entered at Trinity College, Dublin, he studied industriously, if without system, and settled in London to study law. This career he abandoned for literature and politics. He was successively secretary to "Single-speech Hamilton," at that time Secretary for Ireland, and to the Marquis of Rockingham, Prime Minister. He did not hold office until he was fifty-three, and then for a brief period was Paymaster of the Forces. His influence with pen and tongue had no relation to office. His knowledge of public affairs was inexhaustible, his sympathy with the oppressed unfailing. As an orator, he ranks among the greatest produced by this country, though his glowing imagination, his eloquent diction, and passionate delivery did not greatly appeal to the men of his day. His speech at the opening of the trial of Warren Hastings is regarded as perhaps the finest ever delivered in our language; while those attacking the action of the Ministry in regard to our American Colonists, and condemning the French Revolution were, like his writings upon the same subjects, scarcely less resplendent examples of argument and eloquence.

Burns, Robert
b. Alloway, Ayrshire, Jan. 25, 1759. d. Dumfries, July 21, 1796.

The eldest of the seven children of a small farmer, "the boast of Scotland," as Scott named him, received but the meagrest education. At thirteen he was threshing corn for his father, whose chief labourer he became two years later. Before he attained to manhood, he managed to improve his handwriting, and to master French. Latin was too much for him. His first poem was written before he was seventeen, being inspired by a girl with whom he worked in the fields. For a time he studied land-surveying under his uncle; but this, like a subsequent venture in flax-dressing, had no material result. At the death of his father he attempted, with a brother, the task of working an impossible farm. Meantime, he was writing verse. None was published until he had accepted the post of estate-overseer in Jamaica, at £30 per year. His first volume of poems, containing some of his most popular pieces, was issued to pay his passage. Happily, the work came into the hands of Blacklock, the blind poet, who, in a friendly letter, persuaded the friendless youth to abandon his plan of emigrating. The call for a second edition took him to Edinburgh, where he was introduced into the best society of the place. He carried himself with modesty and dignity, and was not spoilt by the admiration he inspired. Determining to "woo his muse at the plough-tail," he took a farm, and, married now to Jeane Armour, sought to make ends meet from this venture, coupled with an Excise Commissionership. The latter yielded him only a clear £40, and at best not more than £70. It had the effect of developing his affinity for evil company, and hard drinking and disregard of health ruined his constitution, and brought him to an untimely grave. His private life was not creditable. That his genius should have burned so brightly under conditions so debasing is greatly surprising. He wrote with remarkable facility. "Tam o' Shanter" was composed during a walk by the Nith; the "De'il's awa' wi' the Exciseman" during a wait by the seashore, and "Scots wha hae" while riding in a storm over the wilds of Kenmure. His works are for all time. "He left his land her sweetest song, And earth her saddest story."

Burton, Sir Richard Francis
b. Barham House, Herts, March 19, 1821 d. Trieste, Austria, Oct. 20, 1890

This daring traveller and indefatigable writer went, disguised as a Mohammedan, to Mecca, and, seeking the sources of the Nile, discovered Lake Tanganyika. Speke, who accompanied him, was sent to explore another lake, and found in it the true source of the Nile Lake Victoria. Burton, who was for many years in the Consular Service, was a roamer almost to his life's end, and was a pioneer in lands which have since become familiar to travellers.

Byron, George Noel Gordon, Lord
b. London, Jan. 22, 1788 d. Missolonghi, Greece, April 19, 1824

Succeeding his grand-uncle in the title and estates, which latter included Newstead Abbey, he studied at Harrow and Cambridge, publishing, when nineteen, "Hours of Idleness." An adverse criticism of this in the "Edinburgh Review" called forth his "English Bards and Scotch Reviewers," published before he had completed his twenty-first year. After Continental travel he married, at twenty-seven, Anne Isabella Milbanke. Their daughter, who afterwards became Countess of Lovelace, was born the same year, and he and his wife parted, under mysterious circumstances, two months afterwards. Byron left England in 1816, and spent some years in Italy, where he took an active interest in the revolutionary movement of the Carbonari. In 1823 he threw in his lot with the Greek insurgents at Cephalonia, became in the following year Commander-in-Chief at Missolonghi, and there died of fever. He died when his intellectual powers were at their zenith. His best known works are "Childe Harold"; a series of dramatic poems, including "Manfred," "Cain," and "Marino Faliero"; also "Mazeppa," "Beppo," and "Don Juan." There remain indelible blots upon his fame as a man, but his nature had its grand and noble and heroic side. His works reflect himself. His poetry is a "dark but divine revelation," and from the dictum of Goethe, that here was a true poet, none now is found to differ.

Cabot, Sebastian
b. Bristol, 1474. d. London, 1557.

The second son of John Cabot, he, with his father, was the first European to see the mainland of North America, anticipating Columbus and Amerigo Vespucci. He sailed from Bristol, and traced the American sea-coast for eighteen hundred miles. Employed at the Spanish Court for some time in correcting maps and charts, he settled down in England as Grand Pilot. His name is also associated with heroic efforts for the discovery of other places not then clearly defined upon the map. He was the first to explain in England the variation of the magnetic needle.

Cadmus

It is difficult to separate legend from the history of the founder of Thebes, in Bœotia. As to his birth and death, dates cannot be given; nor can it be determined whether he was of Phœnician or purely Greek origin. He is credited with having introduced into Greece the Phœnician characters whence was derived the alphabet, the foundation of Western civilisation. Cadmus, the Milesian, the first Greek who wrote history in prose, is supposed to have flourished in the reign of Halyattes in Lydia.

Cæsar, Julius
b. Rome, July 12, 100 B.C. d. Rome, March 15, 44 B.C.

"The foremost man of all this world" was the son of a Roman prætor, or consul. He began his career at twenty, when he was fighting in Mytilene. He was captured by pirates two years later, but, gaining his liberty, rose rapidly to eminence, and, with Pompey and Crassus, formed the first triumvirate. He invaded Britain, then devoted ten years of his life to the complete subjugation of Gaul. So complete was his conquest, and so beneficent his rule, that France was proud of her conqueror. She remained Romanised, she Romanised Germany, and in time sent forth Charlemagne and William the Conqueror. Meanwhile, Cæsar had great battles to fight against the armies of Pompey and Vercingetorix, and, though not invariably successful, finally redeemed Rome from the clutches of an evil oligarchy, and subjected the Empire to his own personal rule. He reformed the calendar, re-cast the administration, and, by a multitude of measures, proved himself as great an administrator as he was a scholar, orator, and soldier. His three and a half years' rule was a period of marvellous achievement for the progress of the world. He was assassinated by conspirators whom he had befriended jealous men who asserted that he desired to make himself hereditary ruler.

Calderon de la Barca, Pedro
b. Madrid, January 17, 1600. d. Madrid, May 25, 1681.

Spain's greatest dramatist was educated as a Jesuit, and was for ten years a soldier before receiving a Court appointment. Afterwards he rejoined the Army, then entered the priesthood, and was, after a further ten years, recalled to Court. He now wrote the plays which his warmest admirers aver entitle him to rank as the "fourth in a mighty quaternion, with Homer, Dante, and Shakespeare."

Calvin, John
b. Picardy, France, July 10, 1509. d. Geneva, May 27, 1564.

The most eminent of the Protestant reformers after Luther embraced the Reformation when nineteen years of age, was banished from Paris three years later; published his famous "Institutes" in 1536 and fled the same year to Geneva. Only two years' rest here was permitted him, for he was banished in 1538, returned three years afterwards, and initiated the Academy of Geneva in 1539. Calvin's services to the cause of Protestantism were inestimable, and his intolerance was not unacceptable in the age in which he so prominently figured. He was a great scholar, a social legislator, and a man distinguished throughout his career by his sincerity and purity of life.

Cano, Juan Sebastian Del
b. Guetaria, Spain, about 1460. d. August 4, 1526

One of Magellan's captains, he succeeded his leader. He was the first man to sail round the world, completing his voyage on September 6th, 1522. He died at sea when on a further expedition.

Canova, Antonio
b. Possagno, Italy, November 1, 1757. d. Venice, October 13, 1822.

From his boyhood he showed his talent for modelling, and at seventeen made himself famous by his statue of Orpheus and Eurydice, which brought him notable commissions. His fame increased with his years. Noble examples of his works are to be seen in the galleries of the Continent. He visited England to pronounce upon the merit of the Elgin marbles.

Canton, John
b. Stroud, Gloucestershire, July 31, 1718. d. March 22, 1772.

Apprenticed to a broadcloth weaver, and afterwards engaged as a schoolmaster, Canton was acclaimed in his day "one of the most successful experimenters in this golden age of electricity." He was the first to show that air may receive electricity by communication, and that water is compressible; he also first manufactured powerful artificial magnets. Nobody in his era did more to advance public knowledge of electricity.

Caracci, Ludovico
b. Bologna, Italy, April 21, 1555. d. Bologna, November 13, 1619.

The son of a butcher, he established the famous Bologna school of painting, and left many fine works. The Caraccis, Agostino and Annibale were his cousins. The last-named, a tailor, eclipsed the works of Agostino, and even of his teacher.

Caravaggio, Michelangelo Amerighi da
b. Caravaggio, Italy, 1569. d. Porto Ercole, Italy, 1609.

A painter of the naturalistic school, two of whose most famous works—"Christ and the Disciples" and "The Entombment of Christ"—are respectively in the National Gallery and the Vatican, he was the son of a mason. The fact that he was guilty of murder may have invested his works with the wild and gloomy character for which they are noted.

Carey, William
b. Paulerspury, Northants, August 17, 1761. d. Calcutta, June 9, 1834

One of the first two Baptist missionaries to India, he was by trade a shoemaker. He proved to have a remarkable faculty for languages, and under his superintendence the Scriptures were published in nearly two score Oriental tongues. He founded the famous Serampur Mission in 1799.

Carlyle, Thomas
b. Ecclefechan, Dumfriesshire, Dec. 4, 1795. d. Chelsea, Feb. 4, 1881.

This sturdy prophet, in the guise of a man of letters, was the son of a worthy stonemason, was educated at Annan Grammar School and Edinburgh University, and maintained himself, while studying law, by giving lessons in mathematics and by writing for encyclopædias. He married, when thirty-one, Jane Baillie Welsh, a woman noted for her wit and beauty. Genius and domestic bliss, unfortunately, are not invariably found beneath the same roof, and the married life of this gifted couple was not happy. Carlyle settled, in 1834, in Chelsea, and there resided to the time of his death, affectionately styled the Sage of Chelsea. There he wrote the works by which he will always be known—"Cromwell," the "French Revolution," "Sartor Resartus," his "Life of Schiller," and translations of that poet's works, and so forth. Chronic dyspepsia aggravated a naturally intolerant, irascible

temperament; but while his faults were hidden from none, his virtues, his nobility of character, his hatred of deceit and meanness and dishonesty were acknowledged even by those at whose foibles he hit hardest. He accepted the Prussian Order of Merit upon the publication of his "Life of Frederick the Great," but refused the pension and decoration which Disraeli offered.

Cartwright, Edmund

b. Marnham, Notts, April 24, 1743. d. Hastings, October 30, 1823.

The inventor of the power-loom and of the wool-comber was a clergyman, who held one or two livings, and, further, was domestic chaplain to two Dukes of Bedford. His inventions, though eventually successful, and of value to the woollen industry, were not productive of profit to himself - partly from their own defects, but chiefly from the prejudice which existed in the minds of workmen. Late in life he received a grant of £10,000 in recognition of his services to trade.

Cary, Henry Francis

b. Gibraltar, December 6, 1772. d. London, August 14, 1844.

The one achievement which entitles Cary to fame is his translation of Dante. It took him many years, and the work was for some time ignored. Coleridge's enthusiastic recognition gave it fame, and its author more fit reward. But he was always in pecuniary difficulties until within three years of his death, when a small pension was conferred upon him. When Cary was translating Dante, Napoleon said of the poet: "His fame is increasing, and will increase, because no one ever reads him." Cary has given Dante immortality in England because everybody does read him—in Cary's meritorious translation.

Catharine the Great

b. Stettin, Prussia, May 2, 1729. d. St. Petersburg, November 17, 1796.

Catherine was one of the most talented and most wicked sovereigns Russia has known. She caused her husband, Peter III., to be deposed and assassinated, and usurped the throne. Next, Prince Ivan, upon whom the hopes of the nation were set, was assassinated. Her private life was scandalous, but her career as a sovereign was in many particulars exemplary. She introduced new laws, reformed the administration, encouraged learning, and left it truly to be said that no sovereign save Ivan the Terrible had so extended the Empire. She had given Russia for boundaries the Niemen, the Dniester, and the Black Sea.

Caxton, William

b. Kent, about 1422. d. Westminster, 1491.

The first English printer was a mercer, who served his apprenticeship in London, and then was for many years resident in Bruges, where he became the head of a company regulating the operations of English merchants in the Low Countries. In 1469 he translated into English the "Recuyell of the Historyes of Troye," and, the demand for the book being so great, he had recourse to printing, which art he had learnt in Bruges. The first book, however, of which we have definite knowledge as to its having been printed at the press which he established in Westminster is the "Dictes and Sayinges of the Philosophers." This made its appearance in 1477.

Cellini, Benvenuto

b. Florence, November 10, 1500. d. Florence, February 13, 1571.

Famous as sculptor, engraver and goldsmith, Cellini devoted the early part of his life to the work of a goldsmith. He was present in Rome during its siege and sack by the Constable de Bourbon. Cellini asserts that he fired the cannon which killed Bourbon and wounded the Prince of Orange. He experienced wonderful vicissitudes - committed murder, was imprisoned, escaped, to renew his fame in fresh directions, in sculpture and engraving. His autobiography is one of the most remarkable works of the character extant, and enjoys universal fame.

Cervantes-Saavedra, Miguel de

b. Alcalá de Henares, Spain, 1547. d. Madrid, April 23, 1616.

The author of "Don Quixote" is supposed to have been educated at the University of Salamanca. He served, however, as a common soldier, and at the Battle of Lepanto, 1571, was so injured as permanently to lose the use of his left hand and arm. The galley in which he was returning to Spain was captured by pirates, and he was detained as a slave for five years in Algiers. After he had been ransomed, it is supposed that he was imprisoned in connection with a debt, and while actually in prison wrote the first part of his immortal work. Upon its publication it leapt at once into popularity; but he did not soon write the second portion, preferring other works, which, while they show the versatility of his genius, are scarcely to be compared with his masterpiece. "Don Quixote" places him in the forefront of the greatest writers the world has known.

Chalmers, Thomas

b. E. Anstruther, Fifeshire, March 17, 1780. d. Edinburgh, May 31, 1847.

This celebrated Scottish author and divine was the father of the Scottish Free Church. He had collected £300,000 for building new churches, and, the dispute over patronage being very keen, he, with 470 other ministers, quitted the parent church and established the new.

Chambers, William

b. Peebles, Scotland, April 16, 1800. d. Edinburgh, May 20, 1883.

The son of a cotton-manufacturer, he, with his brother Robert, founded the publishing-house bearing their name, from which works of the highest educational value to the nation have been issued. The brother, Robert Chambers, who was two years the junior of William, and died in 1871, was the author of many acceptable works. The most notable his "Vestiges of Creation," published anonymously prepared the way for Darwin's "Origin of Species."

Chantrey, Sir Francis Legatt

b. Norton, Derby, April 7, 1781. d. London, November 25, 1841.

Left fatherless when twelve years of age, this son of a carpenter worked in the shop of a Sheffield carver and gilder for five years, then was able to take lessons at the Royal Academy. Having carved a marble bust for a Sheffield church, and others for Greenwich Hospital, he rapidly made himself famous, and executed some of the finest statuary ever done by an English sculptor. He left a fortune of £150,000, from the interest of which our national treasures should be each year enriched, the sum being bequeathed to the Royal Academy.

Charlemagne

b. April 2, 742. d. Aachen, Germany, January 28, 814.

Charles the Great, King of the Franks, Roman Emperor, was the son of Pepin the Short, and succeeded jointly with his brother to the throne of the Frankish kingdom. Upon his brother's death he took the crown to himself. He was a great soldier, a scholar, a born administrator, and the most enlightened ruler of his time. His wars were long and many, but wherever he went the Christianising of his conquered subjects was a paramount consideration. He was crowned Emperor of the Romans in St. Peter's on Christmas Day, 800. His empire extended from the Ebro to the Raab, and from the Eider to the Garigliano, but after his death it was frittered away.

Charles I.

b. Dunfermline, Scotland, November 19, 1600. d. London, January 30, 1649.

This ill-fated monarch takes his place in the gallery of fame not as a great, good, or wise man, but as one whose acts and ends made him the most conspicuous sovereign in our annals. He succeeded his father, James I., on March 27, 1625, and three months later married Henrietta Maria, a Catholic Princess of the Royal House of France.

Persuaded of the divine right of kings, he essayed to govern without Parliament, meeting the expenses of government by forced loans, poundage and tonnage, ship money, and other unconstitutional sources of revenue. His attempts to anglicise the Church of Scotland brought about the Solemn League and Covenant, and led to a bloodless civil war. Parliament, which had not sat for years, was summoned, and the Long Parliament outlasted the King. The revolutionary war extended over four years, and ended in his being taken, impeached, and executed.

Châteaubriand, François René, Vicomte de

b. St. Malo, France, September 14, 1768. d. Paris, July 4, 1848

This celebrated French statesman and man of letters began his career in the army, and after visiting America fought with the Royalist forces at Thionville. Under Napoleon he accepted office, which he relinquished upon the murder of the Duc d'Enghien. Having previously spent some years in England, he now travelled extensively, afterwards supporting the Restoration Monarchy. He was made a peer, and ambassador to England, but revolted against the Royalists until the downfall of Charles X. His writings were many, various, and, for the most part, excellent. He has been called the "Father of the Romantic School."

Chatham, Earl of

b. Westminster, November 15, 1708. d. Hayes, Kent, May 11, 1778.

First a cornet in the Dragoons, William Pitt the elder entered Parliament in 1735, and allied himself with the Prince of Wales, who was then in opposition to the King. Upon the defeat of Walpole he filled minor offices, and in 1757 formed a coalition with the Duke of Newcastle, in which the latter was nominally Premier, while Pitt was so in actuality. His policy of conducting the war against France formed one of the most brilliant chapters in our history, the French being everywhere beaten—in India, in Canada, in Africa, in Europe—on sea and land. He was compelled to resign when his Ministry would not support him in his determination to declare war against Spain. He was Premier again, this time as Viscount Pitt and Earl of Chatham; but his Ministry was helpless without the aid which his ill-health prevented his affording, and his power was gone. He vehemently condemned the policy pursued by this country towards the American Colonies, but was struck down by fatal illness in the House of Lords when declaring against the proposition to terminate the war by granting the Colonists unconditional freedom.

Chatterton, Thomas

b. Bristol, November 20, 1752. d. London, August 24, 1770.

The saddest soul in the history of letters had not completed his eighteenth year when he took his life in a miserable garret in London. Yet how many poets of a later day have his works inspired! He was the son of a sub-chanter at Bristol Cathedral, who left no provision for his boy. Chatterton was bound apprentice to an attorney, in whose house he lived the life of a menial. In his twelfth year he produced the first of the famous "Rowley" poems—his own creation, but which he represented as having been found by himself in the muniment-room of Bristol Cathedral. More followed, and upon his coming to London, and earning eleven guineas, fortune seemed within his grasp. He wrote poems, squibs, stories, essays, letters. "It was Ossian, or a Saxon monk, or Gray, or Smollet, or Junius; and if it failed in most what it affected to be—a poet of the fifteenth century—it was because it could not imitate what had not existed." His patron, Lord Mayor Beckford, died, and, his application for a post as ship's surgeon failing, he was left penniless. He refused a meal offered to him in charity, and took poison.

Chaucer, Geoffrey

b. London (?), 1340. d. London, October 25, 1400.

Chronologically, Chaucer is the first of English poets, and is called the "Father of English Poetry." In point of merit he is among the first of all our poets. He bore arms for twenty-seven years, and was employed on many missions to the Continent. This enabled him to study the Italian poets, by whose example he was inspired. His best known work is "The Canterbury Tales." At later periods of his life he enjoyed considerable Court patronage, but his career was chequered, though not sufficiently to daunt his spirit or extinguish his genius. He was the son of a London vintner and innkeeper.

Cheops

b. 3095 B.C. d. 3032 B.C.

Authorities differ to the extent of two thousand years as to the age in which lived Khufu, the Egyptian King, commonly known as Cheops. He was neither a great man nor good, but he can never be forgotten so long as his vast pyramid at Gizeh, Egypt, exists. It was built for his sepulchre by the labour of hundreds of thousands of slaves, spread over a period of thirty years, and remains to-day the greatest stone building in the world, containing, it is estimated, six million tons of masonry. Cheops was impoverished by the cost of his tomb, and to raise money, it is said, sacrificed the honour of his daughter.

Chesney, Francis Rawdon

b. Annalong, Down, March 16, 1789. d. Mourne, Ireland, January 30, 1872.

A British general and engineer, he established an overland route to India, explored the valley of the Euphrates, and demonstrated the feasibility of a Suez Canal in a report which served De Lesseps as starting-point.

Chevreul, Michel Eugène

b. Angers, France, August 31, 1786. d. Paris, April 9, 1889.

He was for over sixty years chemist at the Gobelins factory, and professor at the French Museum of Natural History. From his labours vast industries have been brought into existence, among his most important discoveries being margarine, olein, and stearin.

Chopin, Frédéric François

b. near Warsaw, Poland, March 1, 1809. d. Paris, October 17, 1849.

Into the forty years of this famous composer and pianist's life was crowded a vast amount of composition—songs, dances, and greater works for the piano—which will long keep his memory green. His association with the famous George Sand extended over eight years. He is the "Prince Karol" of her novel "Lucrezia Floriani," in which she represents him as a "high-flown, consumptive, exasperating nuisance."

Cicero Marcus Tullius

b. Arpinum, Italy, January 3, 106 B.C. d. Formiæ, Italy, December 7, 43 B.C.

One of the greatest orators of his age, Cicero established his reputation as a speaker in his twenty-sixth year, and at thirty pronounced, in denunciation of the infamous Verres, the noble oration which has been preserved to us. As a statesman, Cicero was not robust of will; and, regarded as a trimmer and time-server, he was banished and his house sacked. He was recalled to Rome, but hovered between allegiance to Cæsar and Pompey, finally inclining to the former. He was assassinated in consequence of his indictment of Antony. Inconsiderable as politician and statesman, Cicero excelled as orator and man of letters, and his writings and speeches are dear to all scholars.

Cleopatra

b. Alexandria, 69 B.C. d. Alexandria, 30 B.C.

The last Queen of Egypt was a woman of surpassing beauty and of highly-cultivated mind. She inherited the throne of Egypt jointly with her brother, Ptolemy Auletes, but his guardians denied her right. Cæsar, arriving at this time in

Egypt in pursuit of Pompey, was captivated by her beauty and address, and made successful war in her behalf. She accompanied him back to Rome, and there bore him a son, who was afterwards assassinated by Octavianus.* In the tumult which followed the murder of Cæsar she returned to Egypt, to be summoned to meet Antony at Tarsus, in Cilicia. Antony was not proof against her beauty, and his devotion to her brought about his ruin. He spent the winter with her in Alexandria, then went to Rome to divorce his wife, the sister of Octavian, who thereupon declared war against Cleopatra. Antony joined her, and lost the Battle of Actium. Cleopatra fled, and he, to follow her, threw away half a world. Octavian appeared with his host before Alexandria; and Antony, hearing the false report that Cleopatra was dead, fell upon his sword, while she, to avoid being exhibited at Rome in the triumph of Octavian, took her own life.

Cobden, Richard

b. Heyshott, Sussex, June 3, 1804. d. London, April 2, 1865.

He began life in the warehouse of an uncle, whom he served as clerk and traveller; then, with two others, started a business of his own in London, with calico-printing works in Lancashire, which led eventually to his settling in Manchester. He visited the United States and the Levant, and began his campaign against the Corn Laws. The Anti-Corn Law League, born in Manchester, had Cobden at its head. He preached Free Trade in Parliament and out, and it was due mainly to him and his followers that the Corn Laws were abolished. His devotion to public affairs ruined his business, and, out of gratitude for his services, a national subscription of £80,000 was presented to him. He negotiated an important commercial treaty between France and England, and did useful work for the North in the American Civil War.

Coleridge, Samuel Taylor

b. Ottery St. Mary, Devon, October 21, 1772. d. London, July 25, 1834.

The son of a vicar, who was also a schoolmaster, Coleridge showed as a boy a wonderful avidity for learning, but he left Cambridge without a degree. He got into debt, enlisted, was bought out, acted as editor, lecturer, preacher, and wrote some poems. With Wordsworth, he wrote "Lyrical Ballads," contributing the immortal "Ancient Mariner." Meanwhile, he had married Southey's sister-in-law, and projected, with his two poet friends, a barren scheme for a settlement in the wilds of America. Accepting a pension from the Wedgwoods, he studied for some time in Germany, and upon coming back established himself at Keswick with Southey, and with Wordsworth for neighbour. Here his craving for opium asserted itself, and eventually mastered him. It ruined him mentally and morally. He went to London, where he lectured with varying success on Shakespeare and the fine arts. In London his declining days were passed. His conversational powers were remarkable, and he had many and true friends. As a poet he ranks high, and he was a notable critic. To English literature he rendered invaluable service by infusing into it the spirit of German learning.

Columbus, Christopher

b. Genoa, Italy, about 1435 or 1446. d. Valladolid, Spain, May 20, 1506.

This, one of the most fascinating of all life-stories, began in the humble cottage of a wool-carder. To the same trade as his parent the son was bred, but at a tender age took to the sea. He managed to acquire knowledge of subjects not commonly known at that time, and during all the adventures of his early days—his fights and hair-breadth escapes at sea—this was germinating in his brain, until, arriving at maturity, he resolved upon an attempt to reach India by sailing westward over the open sea. Years elapsed before he could gain the support necessary to equip his ships; but, after heart-breaking discouragements, he set sail, August 3rd, 1492, into the unknown. The wind was fair, and his crew inferred that it always blew in that direction, and, therefore, that they would never be able to return. The variation of the needle, with every other new phenomenon, terrified his crews, who were repeatedly on the point of mutiny. But he held bravely on, and on October 12th, 1492, reached the Bahamas, discovering during his three months' stay Hayti and Cuba. To the whole he gave the general name of the West Indies, so recording his belief that he had reached the Indian Sea. Returning with a greater fleet in the following year, he added little to his first discovery; but at the third attempt, in 1498, he first reached the American continent, near the mouth of the Orinoco. And now, at Hayti, he found the colony which he had established in confusion, and his enemies at home induced the King of Spain to have him brought home in chains. The revulsion of feeling upon his landing in this shameful plight was instantaneous, and he was restored to freedom and honour. Meanwhile, Da Gama had discovered India, in seeking which Columbus had found America. Columbus made another voyage, and explored more of the coast of America, and returned to die in poverty and obscurity. A quarter of a century later Cortez was in Mexico, and Pizarro was conquering Peru. The pilgrimage to the West had begun.

Comte, Auguste

b. Montpellier, France, January 19, 1798. d. Paris, September 5, 1857.

His full name is Isidore Marie Auguste François Xavier Comte. When twenty years of age, the founder of Positivism became the friend and disciple of Saint-Simon; but they took each his own way after four years, and Comte, unaided, founded the school of thought now known as the Positivists.

Confucius

b. Shantung, China, 551 B.C. d. Shantung, 478 B.C.

The name of the great Chinese philosopher was Kung, and we preserve the Latinised form of that name and the term which his disciples applied—literally Kung the philosopher, or the Master Kung. He was the son of a soldier, whose widow was left to educate the child. The latter, when he grew up, was occupied as keeper of the public supply of grain and of the herds. Later he became a wonderfully successful governor, Minister of Works, and chief magistrate of his native place. The jealousy of a powerful neighbour caused his retirement, and from that time forward he wandered for years, attended by his followers, expounding his philosophy. Some of our best-known maxims were first uttered by Confucius. His memory is worshipped to-day in China by every class of the community from the Royal Family downwards, and each town and village must have its temple consecrated to his memory.

Constantine the Great

b. Naissus, Upper Mesia, 272 A.D. d. Nicomedia, Asia Minor, May 22, 337.

Constantine was the son of Constantius Chlorus, who re-established Roman dominion in Britain and became Augustus. His son is commonly called the first Christian Emperor of Rome. As a fact, Constantine, while making Christianity the form of worship for his subjects, was not wholly a Christian until his end was approaching, when he was baptised. Throughout his life he paid official honour to heathen gods. A great soldier and far-seeing administrator, he made himself, after bloody conflict, master of the western portion of the empire, and, finally, emperor of the whole. Having defeated Licinius near Byzantium, he established his capital there, and in 330 inaugurated it under the name of

Constantinople. It was under his auspices that there assembled the great Church Council of Nicæa, at which was produced the Nicene Creed.

Cook, Captain James
b. Marton, Yorks, October 27, 1728. d. Hawaii, February 14, 1779.

The son of a farm-labourer, Cook ran away to sea, and by the time he was thirty-one had attained the rank of master in the Navy, and was given the task of charting the St. Lawrence and the shores of Newfoundland. His work here, as everywhere else, was marked by remarkable thoroughness. He circumnavigated New Zealand, and in the name of his country took possession of the east coast of Australia; circumnavigated the globe near the Antarctic Circle, and explored the Pacific Ocean. He was killed in a quarrel between members of his party and natives in Hawaii. An intrepid voyageur, Cook was a man of noble character, and so universally respected that orders were issued to all French ships by the French Government, during the war of 1779 between France and England, to treat Cook and his vessels as neutral allies.

Copernicus, Nicolas
b. Thorn, Prussia, February 19, 1473. d. Frauenburg, Prussia, May 24, 1543.

Like so many other illustrious men, the father of modern astronomy was the son of humble parents. It was his good fortune to be mentally equipped not only by diligent personal effort, but by a course of study at Cracow University, where he graduated as doctor of medicine. He taught mathematics, became a canon, busied himself with Church work and lay offices. But all his leisure was devoted to astronomy. The so-called Copernican system remained to be established by great men who followed; but he led the way with a new theory, and braved the terrors of the Church to state the case as it appeared to him.

Corneille, Pierre
b. Rouen, France, June 6, 1606. d. Paris, October 1, 1684.

The greatest tragic dramatist of France turned to writing when the attempt to win success at the Bar had failed. He was for some time one of Cardinal Richelieu's "five poets," but was too independent to write at another man's dictation. Corneille ranks with Descartes as the first to free French thought and language from the restrictions due to Latin and Greek influences.

Correggio, Antonio Allegri da
b. Correggio, Italy, 1494. d. Correggio, March 5, 1534.

This great artist takes his name from Correggio, the town near Modena where he was born. Of his work it has been said: "In facility of handling, in absolute mastery of the difficulties of foreshortening, in the management of light and shade as distributed over vast spaces and affecting multitudes of figures, this great master has no rival." The National Gallery possesses some of his masterpieces.

Cortez, Hernando
b. Medellin, Spain, 1485. d. near Seville, Spain, December 2, 1547.

Cortez conquered Mexico for Spain against the orders of Velazquez, who, having given him the command of a small force, sought to depose him. The soldier hurried forward with fewer than six hundred trained warriors of his own nationality and a handful of friendly Indians, a dozen horses, and as many small guns. He founded Vera Cruz, made allies of the Tlascalans, and marched towards Mexico, the capital. Montezuma, the King, came to meet him. He was made prisoner, and siege laid to the capital. A force sent by Velazquez to recall Cortez now drawing near, Cortez took part of his force, defeated the Spaniards, and made the survivors part of his own army, then marched back to Mexico City, to find that those he had left there had been surrounded. Cortez had to battle against a risen nation, and his little force suffered terribly during the retreat from the city. At Otumba he was surrounded, but won a pitched battle against enormous odds, and, having recruited a large number of Indians, returned to the attack upon Mexico. The siege lasted seventy-five days, for the city did not capitulate until its destruction had been practically completed and its population decimated. Cortez had beaten a nation! Expeditions were sent in various directions, and new territories annexed, but Cortez's enemies at home were still powerful. He returned to Spain, and was honoured by his sovereign; but, though appointed captain-general of the New Spain, as it was called, he was not the civil governor. He lived in splendour for several years in Mexico, but, returning for the last time to Spain, died in neglect and obscurity.

Cowper, William
b. Berkhampstead, Herts, Nov. 15, 1731. d. E. Dereham Norfolk, Ap. 25, 1800.

Genius and madness dominated the life of the author of "The Task." A morbid sensitiveness at school made his life hateful to himself. It made him shrink in terror from the duties which should have been his as Clerk of the Journals of the House of Lords. He repeatedly attempted suicide, and was confined as a lunatic. Afterwards began that intimacy with the Unwins which lasted for many years after the death of Mr. Unwin. Later there came into the life of the poet Lady Austen, who told him the story of John Gilpin, and inspired him to write "The Task." He translated Homer, but not with success, and recurrent dementia sadly marred his life. His poetical writings have had a great influence upon English literature, while his letters are a never-failing delight to the student.

Crompton, Samuel
b. Firwood, Lancs., December 3, 1753. d. near Bolton, Lancs., June 26, 1827.

The inventor of the spinning-mule was the son of a small farmer, and helped his widowed mother in farmwork and weaving. The desire to improve upon the old methods, which let the ends of the yarn so readily break, led to his inventing his famous machine. It gave other men vast fortunes, but he reaped little advantage from it, and died poor and in sorrow, defrauded of his just reward.

Cromwell, Oliver
b. Huntingdon, April 25, 1599. d. London, September 3, 1658.

The Cromwells were of good stock—landed gentry, the backbone of the England of those days. Oliver was educated at Huntingdon Grammar School and Cambridge University, then went to London to study law. He became imbued with the tenets of Puritanism, which did not abate their influence when he went down to Huntingdonshire to live the life of an industrious country gentleman. He was returned to Parliament, and it was in the Long Parliament, when he had turned forty, that he first made himself known as above the level of his fellows. When the war with the King broke out, it was Cromwell who most distinguished himself as a soldier. He had had no previous experience, but he proved himself a born general as great in his sphere as any the world has ever known. He raised the famous Ironsides, who were never defeated—neither in our own islands nor on the Continent—nor were his ships otherwise than victorious. He boasted that he would make the name of Englishman as respected as that of Roman had been, and he justified that saying. England under his rule became the sovereign power of Protestant Europe. Meanwhile, however, there was the terrible civil war raging throughout the length and breadth of the land. Cromwell suppressed this with an iron hand, and, plot upon plot originating with Charles I., he had him executed, and himself declared Lord Protector or Regent, as we should now say. His followers wished him to be crowned king, and had he lived longer he would no doubt have yielded to their wishes. At the same time,

however, he did not wish to wound the susceptibilities of the Republican party, and refused the title. He ruled as Protector for less than five years, and in that time proved himself the greatest and mightiest ruler this land has known. The downfall of the edifice which he had raised followed quickly upon his death, and England submitted to Charles II., with his Court of unexampled corruption, debauchery, and shame.

Crookes, Sir William

b. London, June 17, 1832.

From his earliest childhood he has been deeply interested in science, and when still a youth was appointed assistant to Dr. Hoffman at the Royal College of Chemistry. Before he was thirty, a chance observation, made during a spectroscopic examination, led him to the discovery of a new metal- thallium. His method in dealing with this was characteristic. He spent eight years in investigating its substance and properties and weight. One thing led to another. He found that it must be weighed in a vacuum, and this showed that the metal appeared heavier when cold than when hot. This in turn conducted him to his famous researches concerning the discharge of electricity through highly rarefied gases and his examination of radiant matter, all tending towards investigations concerning radium, with which his later years have been engaged. A practical scientist, he has done great things in promoting pure water supply and in the treatment and disposal of sewage.

Curie, Mme. Marie Sklodowska

b. Warsaw, Poland, November 7, 1867.

The daughter of a Professor of Physics at Warsaw College, Madame Curie, from her earliest childhood, was accustomed to the work in her father's laboratory, and came in time to know as much of chemistry as himself. On going to Paris to complete her education, she met and married M. Pierre Curie (b. Paris, May 15th, 1859), and together they discovered radium, and revolutionised the whole world of modern scientific knowledge. The experiments attended by so vastly-important results were conducted when the young couple were very poor. Since then the whole scientific world has paid them honour.

Curwen, John

b. Heckmondwike, Eng., Nov. 14, 1816. d. Heaton Mersey, Lancs., May 26, '80.

As the man who, by the Tonic Sol-fa system, made it possible for the masses to learn music, Curwen is entitled to a place in the gallery of fame. An Independent minister, he was always interested in teaching, and this led to his being asked, at a conference of Sunday-school teachers, to recommend the best and simplest method of music-teaching. As the result, he gave to the world the system with which his name is associated. The principle of that system he seems first to have acquired from a Miss Glover, daughter of a Norwich clergyman. His later years were entirely devoted to the propagation of this system. He wrote many books upon it, and founded the Tonic Sol-fa College. Millions of people owe their knowledge of music to his efforts.

Cuvier, Georges

b. Montbeliard, France, August 23, 1769. d. Paris, May 13, 1832.

The full name of this most famous of comparative anatomists was Léopold Chrétien Fréderic Dagobert Cuvier that given in the heading was his literary style. He filled many offices in the State, and was an indefatigable worker. The theory of evolution found in him a doughty foeman, but his work in comparative anatomy was of vast importance to the science.

Cyrus the Great

b. about 592 B.C. d. 529 B.C.

As to the birth and death of the founder of the Persian empire, fact is less traceable than legend. He was a great warrior, an enlightened administrator, and a humane conqueror. The scene of his conquests lies in the story of the Old Testament. It was he who, after conquering Babylon, permitted the Jews to return to Egypt to rebuild the temple. He not only permitted them to depart in peace, he restored to them the vessels of the temple which had been carried away by Nebuchadnezzar.

Daguerre, Louis Jacques Mandé

b. Cormeilles, Normandy, November 18, 1789. d. France, July 12, 1851.

Skilled as a painter, Daguerre followed up the discoveries of Nicéphore Niepce in obtaining permanent pictures by the action of sunlight, and with him produced the "Daguerrotype" process, the pioneer of modern photography.

Dalton, John

b. Eaglesfield, Cumberland, September 6, 1766. d. Manchester, July 27, 1844

One of the greatest chemists of any age, Dalton was the son of poor parents, his father, a Quaker, being a weaver. It was his fortune to have within reach a cousin who kept a school, at which he was able to develop his love of science. During his life he held many appointments, enabling him to impart his knowledge to others. But he was himself a student all his days. There was so much for him to learn. It fell to him to demonstrate the atomic theory, and new facts innumerable in connection with gases, steam, acids, and so forth. He and his brother were colour-blind, and first drew attention to the existence of this physical disability, hence its early name Daltonism.

Dante, Durante Alighieri

b. Florence, May, 1265. d. Ravenna, Italy, September 14, 1321.

Of honourable and ancient lineage, Dante was the son of a lawyer, and in his young manhood fought with bravery in the wars in which Florence was engaged. He attained to honourable office as a citizen, and successfully discharged civic functions seemingly incompatible with a temperament such as his. In the struggle of his native state to defeat the plan of the Pope to make Florence simply a dependency of the Papacy, Dante took an active part. He was afterwards sent on a mission to the Pope, and never permitted to return. The faction with which he was allied losing the day, a baseless charge of peculation was preferred against him, sentence of banishment passed, followed later by threat of execution; this latter twice repeated. For many years afterwards he was a wanderer, teacher, and student, acquiring that vast store of knowledge which made him the intellectual phenomenon of his age. Florence, which he so loved, he never saw again. His wanderings ended at Ravenna, and there he died. As to the production of his works, no chronological record exists; nor does that much matter. His "Divine Comedia" is known and loved wherever men have a written language. Dante gave Italy a language and a literature. It has been said, "God created Dante and Italian literature together." He began his great work in Latin, but abandoned the project, as Shelley has said, "to create a language, in itself music and persuasion, out of chaos and inharmonious barbarisms." The Beatrice of his dreams was Beatrice Portinari, whom he met when he was a child of nine, and she a few months younger. His passion for her was idyllic. She was married at the age of twenty, and died four years later; and some years afterwards Dante himself married a Florentine lady, by whom he had several children. She remained in Florence after his banishment; but when, later, sentence of death was passed upon her sons with their father, she joined the poet in exile.

Darwin, Charles Robert

b. Shrewsbury, February 12, 1809. d. Down, Kent, April 19, 1882.

Anticipated to a certain extent by his grandfather Erasmus Darwin, the founder of the

Darwinian theory of evolution, raised the crude hypotheses of others to a verifiable theory. Although he was destined for the Church, he was a "born" biologist, and the happy chance by which he was able to accompany the Beagle on her scientific survey gave him several years in which to collect data as to the flora and fauna of many lands. When afterwards he settled down to country life in England, he was able to turn this knowledge to profitable account in his famous "Origin of Species." He devoted years to the compilation of the work, and, as it was, had to be hastened by his friends into publication by the remarkable discovery that Dr. Alfred Russel Wallace was working along lines similar to his own, to the same goal of discovery. Wallace sent his paper on the subject to Darwin, and the latter was prevailed upon to read, with this, one of his own prepared a year earlier, before the Linnean Society. His theory provoked fierce controversy throughout Europe, but to-day is the scientific gospel of the biologist.

Davy, Sir Humphry

b. Penzance, December 17, 1778. d. Geneva, May 29, 1829.

Countless thousands the perils of whose occupations have been lessened by the use of the safety-lamp in mines—think only of Sir Humphry Davy as the inventor of that mechanism. His contributions to science, however, were many and important. He discovered the use of nitrous oxide, and by previously unknown processes proved the existence of numerous metals potassium, sodium, magnesium, calcium, strontium, and barium. His researches had highly important results upon agriculture, while his noble work was of inestimable value in far advancing the outposts of the scientific knowledge of the period. He was the son of a wood-carver, and began life as a surgeon's apprentice.

Defoe, Daniel

b. London, 1659 (?). d. London, April 26, 1731.

The father of Defoe was a butcher, and lived in the parish of St. Giles, Cripplegate. His son received a sound, middle-class education, which the industry of the youth vastly improved. In business Defoe failed as a hosier and as a potter. In politics he was not more to be applauded. Many of his writings were political; but that by which he will always be remembered is "Robinson Crusoe," a work suggested by the adventures of Alexander Selkirk, a marooned sailor. The story is, of course, the creation of Defoe's own brain, but it is a masterpiece of realism, and of simple yet elegant English.

Democritus

b. Abdera, Thrace, 460 B.C. d. about 357 or 370 B.C.

"The laughing philosopher," as he is called, was a man of noblest mind, stored with all the learning of his age. He travelled to wherever knowledge was to be gained. Fragments of his writings which remain show him to have been another Aristotle. His exposition of the atomic theory has been substantially confirmed in successive eras.

Demosthenes

b. Pæania, Greece, 384 B.C. d. Calauria, Greece, October 12, 322 B.C.

Statesman and patriot, Demosthenes was defrauded while a minor of the greater part of his estate. To recover his possessions, he studied law, and became a lawyer and the greatest orator of all time. His "Philippics" were speeches against the encroachment of Philip of Macedon upon Greece. Philip's attack upon the State of Olynthus called forth the "Olynthiacs" of Demosthenes. Perhaps the greatest triumph of his oratory was when he confronted the ambassadors of Philip, and in a great speech induced them to join with Athens against Philip. Very famous, too, is his speech delivered to clear himself of the charge of peculation. Success crowned the arms of Philip and his great son Alexander; but when the latter was dead, Demosthenes headed another revolt, and, being captured by his enemies, took poison.

Descartes, René

b. La Haye, France, March 31, 1596. d. Stockholm, Sweden, Feb. 11, 1650

The father of modern philosophy was educated by Jesuits, but came to the conclusion that he must forget all he had learnt, and instruct himself from the book of knowledge - the world itself. He became a soldier, and fought in several battles; then travelled far, settling eventually in Holland, where for twenty years he studied and wrote. Finally he returned to Stockholm, where he died. He established philosophy upon a new and surer foundation, and presented an entirely new basis for the study of mathematics.

Dewar, Professor Sir James

b. Kincardine-on-Forth, September 20, 1842.

A chemist of world-wide repute, he is the co-inventor of cordite, and was the first to obtain liquid and solid hydrogen. He has been President of the British Association, and the recipient of innumerable degrees and diplomas.

Diaz, President Porfirio

b. Oaxaca, Mexico, September 15, 1830.

The man who has "made" Mexico was intended by his parents to enter the Church, but he chose the sword, and plied it with deadly effect during those stormy days whicl fo[illegible]d the [illegible]ithdr[illegible] of the French troops. He has twice been taken prisoner when engaged in revolutionary fighting, and had the narrowest escapes of death. But, fighting his way to the Presidency, he has remained there term after term, to suppress the revolt, disorder, bloodshed, and dishonesty which he found, and substitute peace and order, good government, commercial prosperity, and security. He has made Mexico the model nation of South America.

Dickens, Charles

b. near Portsmouth, Feb. 7, 1812. d. Gadshill, near Rochester, June 9, 1870.

"Mr. Micawber" is Dickens's own father, which helps us to realise how the son regarded his parent. He was a thriftless, helpless man, first a clerk in the Navy pay office at Portsmouth, and years afterwards a Parliamentary reporter. The novelist had but a meagre education, but read eagerly all the books upon which he could lay hands. When his father lost his situation at Portsmouth, the family lived in poverty in London, and Dickens was compelled to work in a blacking factory, where, for six shillings a week, he pasted labels on the pots of blacking. From this he passed to a further spell of schooling, then had some experience in a lawyer's office, and finally entered journalism as a reporter of Parliamentary proceedings. Collecting some articles which he had written, he published them in book-form as "Sketches by Boz." This attracted the attention of a writer, who was able to recommend him to Messrs. Chapman & Hall when the latter contemplated starting a serial story to run with the illustrations to be drawn by Seymour, the artist. "Pickwick Papers," which began to appear in 1836, when Dickens was twenty-four, was the result. Success was assured after the first few instalments had appeared. Now fairly launched, he wrote "Oliver Twist," "Nicholas Nickleby," "Master Humphrey's Clock," "The Old Curiosity Shop," and "Barnaby Rudge," in rapid succession. He was famous throughout the English-speaking world by the time he had reached the age of thirty. Thereafter his popularity suffered a temporary decline, and it was because he was in debt that he went to Genoa to finish "Chuzzlewit," and afterwards applied unsuccessfully for the position of stipendiary magistrate in London. Upon the "Daily News" being established, Dickens was appointed editor, but

soon relinquished the post to start a paper of his own. The stage had always an attraction for him, and this, as well as the prospect of great pecuniary gain, had much to do with his undertaking his famous readings. These succeeded beyond his wildest hopes in this country and in America, which latter country he visited for the second time when over fifty. He made great sums by his platform work; but the excitement and strain were too heavy a tax upon his energies, and he died suddenly at Gadshill, the home with which he had fallen in love as a youth, and bought as a man. Dickens's married life was not happy, and he and his wife separated twelve years before his death. They had seven sons and three daughters.

Diderot, Denis

b. Langres, France, October 15, 1713. d. Paris, July 30, 1784.

Diderot's forefathers had for generations been working cutlers, and he, receiving a classical education, was the first to break away from the family habit. His father thereupon discarded him, and he set to work to maintain himself by his pen. He undertook, with D'Alembert, an encyclopædia, and for this gathered about him all the greatest writers of France. But the philosophy of the authors was too revolutionary for the official public taste, and again and again Diderot was in danger of imprisonment. The sale was more than once prohibited, and D'Alembert threw up the work in despair. Diderot continued bravely at his task, though it took him twenty years to complete it. He enriched French literature in many ways, and gave a great impulse to intellectual progress.

Diophantus

Lived about 275 A.D.

The writer of the earliest extant treatise on algebra, Diophantus is not clearly to be traced in any records giving data concerning his birth and death. He lived at Alexandria in the third or fourth century, and wrote three works—"Arithmetics" (six of the thirteen books being extant), "Polygonal Numbers," and "Porisms." Algebra was diligently studied in the great days of the Arabian school of learning, but it is believed that the principles of the science were not known before the day of Diophantus. Even if they were so, however, he vastly enriched it. The famous Hypatia wrote a commentary on his works, but this, unfortunately, is not now in existence.

Disraeli, Benjamin, Lord Beaconsfield

b. London, December 21, 1804. d. London, April 19, 1881.

The son of a Jew, Isaac Disraeli, the distinguished man of letters, Benjamin underwent as a child the peculiar rites which made him a member of the Jewish community, but at the age of twelve was baptised at St. Andrew's, Holborn. Having established a reputation with one or two political novels, he travelled, then returned, to stand for Wycombe as an advanced Radical, but was not elected until 1837, when Maidstone chose him. He was now a Tory, and assiduously courted the favour of Peel, but, not winning the recognition he had expected, turned upon and helped to defeat him. Hitherto regarded as a needy adventurer, he now rapidly rose to power—became Chancellor of the Exchequer, and twice Prime Minister. He carried a democratic Reform Bill, abolished Church patronage in Scotland, bestowed upon the Queen the title Empress of India, did a good stroke for his country in acquiring the Suez Canal shares, and embarked upon an Imperial policy as to the wisdom of which politicians differ. To those of his own party he appeared a man of inspiration, of lofty ambitions, and exalted instincts; to his opponents, an unscrupulous, untruthful man, greedy of power, and prepared by any means to gain it. Disliked and distrusted at first by Queen Victoria, he became in time her most trusted counsellor. She made his wife—a wealthy widow, whom he, when thirty-five, had married when she was fifty-six—a viscountess, and in 1876 conferred upon him an earldom.

Dollond, John

b. London, June 10, 1706. d. London, November 30, 1761.

The inventor of the achromatic telescope was the son of silk weavers, who had fled to England on the revocation of the Edict of Nantes. He learned his parents' trade, and was compelled, by the early death of his father, to forgo any ordinary education. But he denied himself sleep that he might study, and acquired languages and scientific knowledge with extraordinary facility. It was not, however, until he had a grown-up son that he forsook silk-weaving to apply himself practically to optics and invent the telescope, by which he is rendered for ever famous. After his death a curious fact was established. Dollond's discovery had been anticipated by thirty years. Another student had produced an achromatic telescope. This was clearly established in evidence upon trial, but the court held that the Dollonds' rights had been invaded when the earlier instrument was now placed upon the market. Hall, the other inventor, had "confined the discovery to his closet, and the public were not acquainted with it, and Dollond was to be considered the inventor." The lesson from this decision, which still holds good in law, is obvious.

Dryden, John

b. Aldwinkle, Northants, August 9, 1631. d. London, May 1, 1700.

A son of the parsonage, Dryden was first sent to Westminster, then to Cambridge, and entered upon his career as a sturdy Parliamentarian. He became eventually a convert to the Royalist side, and was Poet Laureate and Historiographer Royal, and at fifty-five seceded to the Roman Catholic Church. The sincerity of this conversion, coming with the accession of James II., has been impugned; but it seems to have been one of conviction, for when the Revolution was effected Dryden declined to take the oath, though his refusal cost him all hope of official emolument. He wrote his many plays solely for profit. His critical work, his poems, and his satires, were dearer to his heart, and among the finest works in the language. His translations, too, were admirable. He was a great master of pure English bold, vigorous, original, with a perfect ear for the melody of language—and wrought a revolution in prose and versification.

Dumas, Alexandre

b. Villiers-Cotterets, France, July 24, 1803. d. Puys, France, Dec. 5, 1870.

His father, General Alexandre Davy de la Pailletrie Dumas, was a famous soldier, son of a marquis and a Haytian negress named Dumas. The novelist and playwright had for his mother the daughter of a tavern-keeper. He was first a clerk, but devoted some years to study, with a view to a literary career. Once launched upon the sea of letters, his output was little short of marvellous. "The Three Musketeers," "The Black Tulip," and "Monte Cristo," and other works by which he is rendered famous throughout the world, were only items in an unparalleled flood of books. He was a terrible plagiarist—put his name to other men's work, and is even said to have contemplated issuing as his own story a prose version of part of Homer. He had nearly five score men as collaborators at one time and another during his career. They supplied plots and descriptions, but Dumas put magic into the scenes, and breathed life into the figures.

Edison, Thomas Alva

b. Milan, Ohio, U.S.A., February 11, 1847.

One of the most striking examples of what can be achieved when genius is supported by courage and determination, Edison's career was for years

a struggle against disadvantages. He had little education, and when twelve years of age was turned out to earn his living as a newspaper-seller on a railway. He managed to set up a small printing-press on board a train, and to edit and print, and sell his own paper. In his spare moments he studied chemistry, and persuaded a telegraph-operator to teach him telegraphy. This led to his first invention, the duplex telegraph, by means of which messages can be sent from one wire to another without the aid of the operator. The printing telegraph machine followed, and after that, patent upon patent, the carbon telephone-transmitter, the microtasimeter, the aërophone, the megaphone, the phonograph, the incandescent lamp, and electrical appliances innumerable. The incandescent arc lamp he invented to suit his own wants. He could not get sufficient light to carry out the work upon which he was engaged, and never rested until he had devised his new method of illumination.

Elgar, Sir Edward

b. Broadheath, Worcestershire, June 2, 1857.

The greatest living English composer is an entirely self-taught man. His father was an organist, but Sir Edward cannot remember ever having a music lesson. For twenty years he studied and composed without recognition, but since then he has gained the highest honours in England and on the Continent, and is regarded not merely as the greatest master of English music, but as the foremost composer of the age.

Eliot, George

b. near Nuneaton, Warks, Nov. 22, 1819. d. Chelsea, Dec. 22, 1880.

One of the greatest novelists produced by England, "George Eliot" was in private life Mary Ann Evans, youngest daughter of a carpenter, turned land-agent. She received a sound education, and when her school-days proper were ended had lessons in German, Italian, and music. Her first literary effort was a translation of Strauss's "Leben Jesu," and this brought her in touch with the editor of the "Westminster Review," whom, after she had visited the Continent, she joined as assistant editor. She lived with the Chapmans, and there met all the literary lions of the period. Among them was George Henry Lewes, to whom she was introduced by Herbert Spencer. Lewes was married, but separated from his wife. The friendship of the young people ripened into affection, and they agreed to set convention at defiance. They lived together as man and wife until Lewes died. Her first effort in fiction, undertaken at the suggestion of Lewes, appeared in a magazine, under the pseudonym which she afterwards retained. Its success encouraged her to write "Adam Bede," which won for her an immense triumph. "The Mill on the Floss," "Silas Marner," and "Romola" followed, each gaining for her new laurels, but each making her writing more than ever a matter of anxiety. Towards the close her work suffered from over-elaboration, and too great care. Nevertheless, "Middlemarch" is considered by some her best work, even though one authority declared "Adam Bede" the "finest thing since Shakespeare." She wrote some poems, but it is as a novelist that George Eliot will always be remembered. Two years after the death of Lewes she married his and her old friend, Mr. John Cross, who afterwards wrote her life. She died the same year. Mr. Swinburne has said of her: "In George Eliot it is the most vivid and vital impulse which lends to her large intelligence the utmost it ever has of the spiritual breath and living blood of genius, and never had anyone such gift more plainly and immediately as from the very heart of heaven."

Elizabeth, Queen

b. Greenwich Palace, Sept. 7, 1533. d. Richmond, March 24, 1603.

It was the happy fortune of Queen Elizabeth to be born in an age of great men, an era which knew Shakespeare, and Spenser, Sidney, Raleigh, Howard, Drake, Hawkins, and the illustrious Lord Burghley. With skilful counsellors about her, and valiant men to do her bidding, she, with her "King's heart, the heart of a King of England," as she said, was bound to rank high in the roll of British sovereigns. Her early days were spent in obscurity. The daughter of Henry VIII. by his second wife, she was declared illegitimate. When her half-sister Mary ascended the throne she was subjected to close confinement, being suspected of complicity in Protestant conspiracies. Called eventually to the throne, she took the most important step of her life when she declared for a Protestant England, and refused the hand of Philip of Spain. Mary Queen of Scots was the centre of innumerable plots, and Elizabeth had her imprisoned, and, in the end, executed. This act was made the pretext for invasion by Philip of Spain; and the destruction of "the invincible Armada" was the result. English influence was vastly extended in Europe by Elizabeth, who made her country a world power for the first time. Her reign was distinguished for the advancement of learning, for the extension of commerce and enterprise, and, most of all, of course, for the establishing on a firm basis of the Protestant religion. Personally, Elizabeth was not an ideal character. She was vain and coarse, fickle and revengeful. She was a king in petticoats, but with the weaknesses of a woman of feeble character. Although she was too masterful to admit any special powers in Parliament, she prided herself on basing her rule on the confidence and affection of the people. Deficient in many amiable and moral qualities, she yet proved herself one of the greatest of sovereigns.

Emerson, Ralph Waldo

b. Boston, Mass., May 25, 1803. d. Concord, Mass., April 27, 1882.

"The Buddha of the West," as a distinguished admirer has called him, was for a few years a Unitarian minister at Boston. The views of his congregation not according with his own, he quitted the pulpit, to be henceforth known as lecturer, essayist, and poet. His works, which are as widely read in the Old World as the New, are an unfailing inspiration to the thoughtful. He was an idealist, an invincible optimist, and in religion a rationalist. Twice he visited England, and on the second occasion delivered a notable series of lectures on "Representative Men." His friendship with Carlyle dates from his first arrival in England. Emerson was twice married.

Empedocles

b. Agrigentum, Sicily, 500 B.C. d. Sicily, about 430 B.C.

Sufficient is now known of the life of this famous Sicilian philosopher and physician to dispose of the story that he threw himself into the crater of Etna. His fame and liberality were such that the people wished to make him king. This offer he declined, and established instead a democracy. His philosophy embodied the belief that the world was evolved from fire, air, water, and earth, and that the reverse process of dissolution proceeded under the varying struggle between forces termed affinity and antipathy.

Encke, Johann Franz

b. Hamburg, Germany, Sept. 23, 1791. d. Spandau, Prussia, Aug. 26, 1865.

Famed for his investigations as to the comet now named after him, Encke, who was a soldier before turning to astronomy, solved the problem of the sun's distance. He studied at Göttingen, and was successively astronomer at Seeberg and director of the Berlin Observatory.

Ennius, Quintus

b. Rudiæ, Calabria, 239 B.C. d. Rome, 169 B.C.

He was the pioneer of literature representative of Rome. A soldier, he returned from the wars under the patronage of Cato the Elder, through whose influence Ennius, believed to be of Greek extraction, was made a Roman citizen. He taught Greek, and wrote in almost every style of poetry. His work first gave to Latin literature a character of serious elevation.

Erasmus, Desiderius

b. Rotterdam, Holland, Oct. 28, 1466. d. Basel, Switzerland, July 12, 1536.

The father of Erasmus was the hero of Charles Reade's "Cloister and the Hearth," and the philosopher's real name was Gerrit Gerritszoon. The two terms which he adopted—the first Greek, the second Latin—have the same meaning—"the desired, lovable." During his father's lifetime Erasmus was well cared for, and learned Greek, but afterwards he was defrauded of his inheritance and forced into a monastery. His scholarship won him the patronage of the Bishop of Cambrai, who enabled him to study in Paris. Thereafter he travelled throughout Europe, was released from his monastic vow, and for some years held a professorship at Cambridge University. He was forty-nine when his great work—the first edition of the New Testament in Greek—was published. His original writings, wise and witty, came afterwards. Although he exposed the abuses of the Catholic Church, he would not take any share in the Reformation, and would have been made a cardinal had not death prevented it.

Ericcson, John

b. Vermland, Sweden, July 31, 1803 d. New York, March 8, 1889

A born inventor, who before he was nine had constructed a working model of a water-power sawmill, Ericcson was compelled to waste several years of his life in the Swedish army. All his leisure was devoted to planning mechanical contrivances, and upon coming to England he built a steam-engine to compete against Stephenson's famous "Rocket." Ericcson's ideas were ahead of the times. His steam fire-engine was rendered a failure by popular prejudice and ignorance; while the story of his efforts to induce the Admiralty to test his screw propeller for steamships is historic. He designed the first vessel driven in this manner across the Atlantic, and himself took up his residence in America, where the reception of his schemes was scarcely more friendly than had been the case in England. In spite of all obstacles, he completely revolutionised marine navigation and the building of warships. From his schemes endless achievements have resulted, while the inventions which he carried to perfection serve still as finger-posts for others' guidance.

Euclid

b. Alexandria, about 300 B.C. d. Alexandria, date unknown.

Beyond the fact that he flourished in Alexandria under the first of the Ptolemies, about 300 B.C., dates as to the career of this famous mathematician are not available. It is believed that he founded the great mathematical school of Alexandria, so performing a service of prime importance to the cause of exact science. His chief work extant is the "Elements," which to this day continues the textbook for elementary geometry in the United Kingdom. He did not invent the system to which his name is given. He compiled, arranged, and permanently recorded known mathematical truths.

Euripides

b. Salamis, Greece, 480 B.C. d. Macedonia, 406 B.C.

The last of the Greek tragedians, and the model upon whose style the modern French and Italian drama is fashioned, was born when heroic history was being made by Greece. He did not catch the martial spirit of the age, but passed his youth in study, he became a poet, philosopher, and dramatist of infinite power and passion, and of inexhaustible love for the weak and suffering. Of his eighty plays, eighteen are preserved.

Eyck, Jan Van

b. Maaseyck, Prussia, about 1390. d. Bruges, Flanders, July 9, 1440.

With his brother Hubert—who was twenty years his senior, and died in 1426—he first perfected the system of mixing colours with oils for painting. The brothers painted together as a rule. Their greatest work—the altar-piece for the cathedral at Ghent—was one of their joint efforts. In the National Gallery, London, are fine examples of Jan's individual work.

Fahrenheit, Gabriel Daniel

b. Dantzic, Prussia, May 14, 1686. d. Holland, Sept. 16, 1736.

He was the first to substitute mercury for spirits of wine in the thermometer. The thermometric scale to which he gave his name he fixed as follows: Zero was the lowest temperature observed by him at Dantzic during the winter of 1709; the space between this point and that to which the mercury rose at the temperature of boiling water he divided into 212 parts. He was an F.R.S. of England, and had some celebrity as a practical engineer.

Faraday, Michael

b. London, Sept. 22, 1791. d. Hampton Court, Aug. 25, 1867.

Newington Butts was the birthplace of Faraday; a blacksmith, his father. He received but a scanty schooling, and owed to an accident his chance of winning success in life. He was apprenticed to a bookbinder, one of whose customers, attracted by the intelligence of the apprentice, gave him four tickets for Sir Humphry Davy's lectures at the Royal Institution. Of this opening Faraday took such advantage that Davy, reading his notes on the lectures, appointed him his assistant and amanuensis, and took him for a tour on the Continent. Later, Faraday was appointed professor of chemistry at the Royal Institution, and for the rest of his days devoted himself to scientific research. His discoveries covered the whole field of magnetism, diamagnetism, electromagnetism, and electricity proper. He elucidated the application of induced electricity to lighthouses, the firing of mines, telegraphy, and the magnetic currents of the earth. Within the space at command it is impossible even to indicate the number and scope of his discoveries of first importance. His lectures were famous, his writings models of lucidity and pure English. Few great men have received a more slender educational equipment, but none has eclipsed the importance and varied character of his investigations.

Fawcett, Henry

b. Salisbury, Aug. 26, 1833. d. Cambridge, Nov. 6, 1884.

Fawcett's life-story is another exemplification of the fact that will is greater than physical faculties. He was blinded when a youth by a shot from his father's rifle, but bravely bore his handicap, became a member of Parliament, and as Postmaster-General gave us the parcel post, postal orders, and the sixpenny telegram.

Ferguson, James

b. Keith, Banffshire, April 25, 1710. d. London, Nov. 17, 1776.

The man who, by his lectures and writings, and still more by his mechanical appliances, did much to popularise astronomy in England, was almost wholly self-taught. He learned to read from hearing his father teaching his brother. He gained his first idea of mechanics by seeing his father plying the lever. While working as a shepherd boy he made models of mills and other machines, and at night studied the stars, and planned the heavens with beads strung upon threads. For some years he was able to maintain his family by painting miniature portraits.

Fichte, Johann Gottlieb
b. Rammenau, Germany, May 19, 1762. d. Berlin, Jan. 27, 1814.

A son of poor parents, Fichte lacked the means to qualify for the Church, so took service as a tutor until he could afford to devote himself wholeheartedly to the teaching of Kant. He published an essay which was mistaken as being from the pen of that philosopher, and this proved the making of the younger man's reputation. He was appointed professor of philosophy at Jena, and there remained until he was falsely charged with Atheism. He removed to Berlin, where he lectured and wrote. Napoleon's great victories over the Germans called forth Fichte's famous Addresses to the German nation, in which he pointed out that the true way to national regeneration lay in a system of public education. After the war Fichte was invited by the king to draw up a constitution for a new university, and became its first rector. He died of fever, contracted through nursing his wife, who had herself taken it while tending the wounded German soldiers, of which the Berlin hospitals were full.

Fielding, H nry
b. Glastonbury, Somerset, April 22, 1707. d. Lisbon, Oct. 8, 1754

"The father of the English novel" was the son of a general, and half brother of Sir John Fielding, the famous blind magistrate of Bow Street. He became a theatre proprietor, but his bold attack upon the ministry of the day led to his being driven out of this venture. He was called to the Bar, but turned to literature, to write the novels which have made him immortal.

Finsen, Niels Ryberg
b. Faroe Islands, Denmark, 1861. d. Copenhagen, Sept. 24, 1904.

Crowned by the discovery of the application of light to the cure of disease, Finsen's career was one long battle against disease. Twenty years before the end came he knew that he was a doomed man, yet sought the physical salvation of others, though he knew that his own life was ebbing away. His famous light cure for lupus was first made popularly known in England through the wisdom and goodness of Queen Alexandra.

Flaxman, John
b. York, July 6, 1755 d. London, Dec. 7, 1826.

Destined to rank at the head of English sculptors for inventive power, controlled by unerring sense of beauty, Flaxman was the son of people in the poorest circumstances. He himself was seriously deformed. His genius discovered itself when he was engaged by the Wedgwoods to draw designs for their pottery. He taught himself Latin and Greek enough to enable him to read the poets, and spent seven years in Italy, where he executed numerous classical groups and drew illustrations for Homer. From his return to England to the end of his days he was engaged upon monumental sculpture, though he found time to discharge the duties of professor of sculpture to the Royal Academy.

Fo-Hi
flourished about 2400 B.C. d. Chiu-Choo.

China gets her political and social system from Fo-Hi, who is supposed to have lived in the twenty-fourth century before the Christian era. Marriage, the division of time and of seasons, the calendar, the use of metals and minerals, of building, fishing, and hunting, are among the institutions said to have been originated by this representative of the founders of the oldest known civilisation

Fox, Charles James
b. London, Jan. 24, 1749. d. Chiswick, Middlesex, Sept. 13, 1806.

"The greatest debater the world ever saw" was Burke's description of Fox. He was the third son of the first Lord Holland. In Parliament he opposed the coercion of our American colonists and the war with France. Although George III. cordially disliked him, he was twice Foreign Secretary. He was engaged upon a bill for the abolition of slavery when laid low by death. Fox's private life was deplorable.

Fox, George
b. Fenny Drayton, Leicestershire, July 1624. d. London, Jan. 13, 1691.

The founder of the Society of Friends, or Quakers, was a worthy itinerary preacher who, the son of a weaver, served an apprenticeship to bootmaking. His outspoken denunciation of forms of worship of which he did not approve caused him to be the victim of repeated persecution and imprisonment. But he made converts wherever he appeared, and they suffered with him. During the latter part of his career he was accompanied by Penn, and visited, among other places, America and Holland.

Francis, St., of Assisi
b. Assisi, Italy, 1182. d. Assisi, Italy, Oct. 4, 1226.

His surname was Bernardone. A serious illness turned him from a life of profligacy to that of an ascetic, vowed to chastity and poverty. He gathered about him others who subscribed to the conditions, and founded the famous Franciscan brotherhood. After a visit to Egypt, where he preached before the Sultan, and obtained for his order the guardianship of the Holy Sepulchre, he retired to a hermit's cell, where tradition alleges he received upon his own person the wounds of the Saviour. He was canonised two years after death.

Franklin, Benjamin
b. Boston, Mass., Jan. 17, 1706 d. Philadelphia, April 17, 1790.

The man who, by a novel experiment, was to discover that lightning and electricity are identical, to establish the distinction between positive and negative electricity, and achieve other scientific triumphs, began his career as a "printer's devil" in the newspaper office of one of his brothers. His life was amazingly active. He set up a press of his own in Philadelphia after having worked for eighteen months in a London printing-office, published with unprecedented success "Poor Richard's Almanack," returned to England on a diplomatic mission, and was honoured by scientific bodies and both Universities. While carrying on his business as a newspaper proprietor he discharged more or less important offices under Government, and at the same time conducted scientific investigations as to tides, meteorology, and colours. Prior to the War of Independence he came again to England, in the hope of securing the rights of his fellow colonists. Failing, he returned, took an active part in preparing the Declaration of Independence, then proceeded to Paris, and negotiated a treaty whereby France recognised the new Republic and lent armed assistance. Eventually he opened a correspondence with England which paved the way to peace. Thereafter he was American Ambassador to France, and subsequently filled various offices at home. One of the most completely successful men of any age in all the branches of activity in which he engaged. Franklin left behind him writings which to this day continue to be read by every nation which has a written language.

Franklin, Sir John
b. Spilsby, Lincs., April 16, 1786. d. King William's Land, June 11, 1847.

He discovered the North-west Passage, but died, probably starved to death, in the scene of his triumph. After serving at the Battle of Copenhagen and at Trafalgar, and mapping parts of the coast of Australia, he twice commanded Arctic exploring expeditions, and received honourable reward for successes gained. For seven years he was governor of Van Diemen's Land (Tasmania). On May 18th, 1845, he sailed in command of the two

Government ships Erebus and Terror, and never returned. In the twelve years following his departure thirty-nine relief expeditions were sent out by England and America. The last—one of five despatched by his widow—discovered all that there was to be learned. The party had suffered frightful privations, and had all died. A memorandum was found giving the date of Sir John's death. Some of the victims had resorted to cannibalism in their agony of starvation.

Fraunhofer, Joseph von

b. Straubing, Bavaria, March 6, 1787. d. Munich, June 7, 1826.

A skilled optician, who did much to improve the telescope and other optical instruments, he is chiefly famous as the discoverer of the dark lines in the sun's spectrum, named, in his honour, "Fraunhofer's lines."

Frederick II., The Great

b. Berlin, Jan. 24, 1712. d. Sans Souci, Potsdam, Aug. 17, 1786.

When Frederick came to the throne of Prussia, Germany was loosely ruled by some three hundred men of different titles. There was no cohesion or national spirit, so when the Emperor Charles VI. of Germany died, and the validity of his daughter's succession was impugned, Frederick determined to take Silesia, part of which had anciently belonged to Prussia. The number of his people was inconsiderable—only half that of London—but he had a highly-organised army of eighty thousand men and a well-filled treasury. He was everywhere successful, and added Silesia to his own dominions. An alliance which he had concluded with France and Bavaria was now terminated, but he was afterwards forced to renew this and to enter upon a second war. His third and last war was the greatest and most terrible. Allied against him were France, Austria, and Russia, an unparalleled combination. England had been helping him with subsidies, but this source of revenue was stopped. What would have happened had not the Empress of Russia died, and the course of events been thus unexpectedly altered, it is difficult to imagine. He had fought with magnificent skill and courage, but the odds had become overwhelming. Still, he had not allowed his country to incur one penny of debt, though the land had been reduced almost to starvation. The latter part of his reign was spent in peace. He added a part of Polish Prussia to his dominions, and he retained Silesia. For the rest, he was happiest when promoting the educational and material interests of his people. He loved literature and the arts. He was a friend of Voltaire, and had him for some time at Berlin. Frederick deserved the appellation "The Great." Had not his time been so much occupied with wars, he would have proved a still greater man.

Froissart, Jean

b. Valenciennes, France, 1337. d. Chimay, Belgium, about 1410.

The chronicler of the knightly doings in Court and camp of the fourteenth century was the son of a Flemish painter of armorial pictures. Showing aptitude for poetry, he attained Court favour and a recommendation to the English Court, where he was patronised by the Queen of Edward III. Thus favoured, he made tours throughout this country, and afterwards in France, Germany, Italy, and Spain, and collected also details as to Hungary and the Balkan Peninsula. His influential introductions and his own pleasant bearing and address served to bring him tales of chivalry, and of more serious affairs wherever dames and knights or squires assembled. He gives us a delightful picture of the Europe he knew from the third decade to the end of the last of the fourteenth century. His poems and romances have merit, but the "Chronicles" are for all time.

Fuller, Thomas

b. Aldwinkle, Northants, June, 1608. d. London, Aug. 16, 1661.

This witty divine and historian was a son of the rectory, and as a youth imbibed principles which made him all his life a sturdy Royalist. He suffered for his loyalty, but made good his losses at the Restoration. Of his writings, the most famous is his "English Worthies," a posthumous publication, to which he had devoted twenty years' work. It is one of the great classics of the language. "A tithe of his beauties," says Coleridge, speaking of his style, "would be sold cheap for a whole library of our classical writers, from Addison to Johnson, and Junius inclusive."

Fulton Robert

b. Little Britain, Pa., 1765. d. New York, Feb. 24, 1815.

Born of Irish parents, Fulton came to London to study portrait painting, but after some years devoted himself wholly to engineering, and was the first successfully to apply steam to navigation. He had many disappointments with other inventions, prejudice and ignorance being in alliance against him.

Gabelentz, Hans Conon von der

b. Altenburg, Germany, Oct. 13, 1807. d. Triptis, Germany, Sept. 3, 1874.

One of the most gifted of philologists, he was master of eighty languages. He wrote upon tongues of which previously little had been known. His son, who outlived him only nineteen years, was an accomplished Orientalist.

Gainsborough, Thomas

b. Sudbury, Suffolk, May, 1727. d. London, Aug. 2, 1788

In the estimation of Ruskin, Gainsborough was the greatest colourist since Rubens. The son of a wool manufacturer, he showed from the earliest age a gift for sketching, and when fourteen was sent to London to study. Four years later he returned to his native place, married a lady with means, and set up a studio as a portrait painter—first at Ipswich, then at Bath. There he remained for fourteen years, painting many fine portraits. Removing to London, he became one of the founders of the Royal Academy, from which he withdrew four years before his death, annoyed at the position awarded to his picture, "The King's Daughters." His works numbered upwards of three hundred, of which more than two-thirds were portraits. Gainsborough was a man of impetuous temperament, but on the whole singularly lovable, musical, sociable, generous, loyal.

Galen, or Claudius Galenus

b. Pergamos, Asia Minor, 131 A.D. d. Sicily (?), about 200 A.D.

This celebrated Greek physician and philosopher revived the old systematic study of medicine and surgery, and enriched it with independent research of inestimable value. He was the standard authority and fount of learning to whom students turned for the next twelve centuries. He travelled far in quest of knowledge, but was driven from Rome by the jealousy of the physicians there. Of his treatises, some four score remain to us—valueless now in the light of modern knowledge, but wonderful records of the industry and talent of a man vastly ahead of his time.

Galileo

b. Pisa, Italy, Feb. 15, 1564. d. Arcetri, Florence, Jan. 8, 1642

Galileo Galilei, the father of physics, was descended from a noble but impoverished Florentine family, originally named Bonajuti. As a child he displayed versatile genius in music, in modelling, in painting, and in mechanics. While in his youth he invented the first instrument ever devised for accurately observing phenomena in a living organism—a pendulum for recording the speed of the pulse. After studying at Pisa University, he constructed a thermometer, improved the telescope, and turned it for the first time towards the heavens, with the result that he discovered the satellites of Jupiter, proved the

existence of sun-spots, and became persuaded of the truth of the Copernican theory. He carried the subject much farther, and, the attention of the theologists thus drawn afresh to the matter, the works of Copernicus were placed on the "Index Expurgatorius," and Galileo compelled to vow that he would not defend their teaching. Some years later his own "Dialogues of the Two Systems" was published. Thereupon he was summoned to Rome, and compelled, under threat of death or torture, to sign a formal abjuration of the Copernican doctrine. He yielded, and did not suffer the torture commonly believed to have been his fate. But his activities were not checked. He worked on, even when sight failed him, preparing the way for Newton and the other giants who were to follow.

Gall, Franz Joseph
b. Tiefenbronn, Baden, March 9, 1758. d. near Paris, Aug. 22, 1828.

He is commonly called the founder of phrenology. He never used the latter word; his disciples, who are said to have resembled him only in his mistakes, coined it. Their master did not make conformation of the skull the foundation of his system. The functions of the brain itself were his study. He was the son of a physician, and was prohibited from lecturing in Vienna on his theories, on the ground that they were subversive of religion. He lectured through a great part of Europe, and became famous as a physician in Paris, where his closing years were passed.

Galton, Francis
b. Birmingham, 1822.

A grandson of Erasmus Darwin, and cousin of Charles Darwin, he has gained distinction as explorer and philosopher. His researches have done much to advance the knowledge as to heredity. Latterly he has rendered a public service by investigations of finger-prints. His calculations go to prove that the chances against the impressions made by two different fingers resembling each other are one to 64,000,000,000. He thus places at the disposal of the authorities a potent means for the detection of criminals.

Galvani, Luigi
b. Bologna, Italy, Sept. 9, 1737 d. Bologna, Dec. 4, 1798

A noted physician and physicist at Bologna, he conducted experiments with metals placed in contact with the muscles of dead frogs, and came to the conclusion that electricity or magnetism was an animal product. He was wrong, of course; but he has an important place in the story of knowledge, inasmuch as it was his experiments which gave Volta a clue to the important solutions at which he was able to arrive. Galvanism takes its name from Galvani.

Gama, Vasco da
b. Sines, Portugal, about 1460. d. Cochin, India, Dec. 24, 1524.

Charged by his sovereign with the duty of finding a sea route by way of the Cape to India, Da Gama valiantly discharged his mission, established a Portuguese station at Calicut, Malabar, and returned. A succeeding mission was massacred, and Da Gama led a punitive expedition in consequence, and afterwards went out as Viceroy. His work was destined enormously to enrich Europe, and England in particular.

Garibaldi, Giuseppe
b. Nice, Italy, July 4, 1807. d. Caprera, Italy, June 2, 1882.

The son of a seafaring man, and educated for the Church, Garibaldi preferred the sea, became involved in the Young Italy movement, was sentenced to death, but escaped to South America, where he fought in more than one revolutionary war. His return to Italy was followed by another flight to America, where he followed the trade of a candle-maker. This occupation gave place to that of a farmer on the Island of Caprera, near Sardinia, which, by the generosity of English admirers, was, later in his life, made his own property. From this point, until the liberation of Italy was consummated, his days were given to fighting for the freedom of his native land. He was a born leader of guerilla troops, but not gifted in statesmanship, and his career included many mistakes, for which he paid dearly. But he was a sincere, unselfish patriot, and in England was treated as a hero.

Gay-Lussac, Joseph Louis
b. St. Leonard le Noblat, Haute-Vienne, 1778. d. Paris, May 9, 1850.

Distinguished as physician and chemist, he is renowned for his researches on chemical combinations, the results of which were highly important to commerce. He made the discovery of the law of volumes, and was the first man to make a balloon ascent for scientific purposes.

Ged, William
b. Edinburgh, 1690. d. Leith (?), Oct. 19, 1749.

The man who first invented stereotyping, a highly important advance upon the original method of printing from the old movable types, had all his life to fight ignorance, prejudice, and jealousy. These won the day, and, in spite of the manifestly valuable character of his work, he died broken-hearted and in abject poverty.

Gibbon, Edward
b. Putney, April 27, 1737. d. London, Jan. 16, 1794.

"It was at Rome, on the 15th of October, 1764, as I sat musing among the ruins of the Capitol, while the barefooted friars were singing vespers in the temple of Jupiter, that the idea of writing the decline and fall of the city first started into my mind." So came the inspiration for our greatest work in history, "The Decline and Fall of the Roman Empire." A work of such magnitude and splendour could hardly have been expected of the man. He had had little regular scholastic training, owing to ill-health. His stay at Oxford resulted in his conversion to Roman Catholicism. This caused his father, a man of comfortable circumstances, to send him for five years to Lausanne, where the judicious handling of a Calvinistic tutor brought him back to his first faith. Here Gibbon read prodigiously, and remembered what he read, and stored up the knowledge which was to serve him for his great work. He had a love affair here, of which the heroine was to become the wife of M. Necker, and mother of the famous Madame de Staël. Upon the death of his father, he sat for some years in Parliament, but never addressed the House, and though he was granted a sinecure office it lasted but three years. The preparation of his first volume of the history occupied him many years. The others were written with striking rapidity, and the last was published six years before his death, which occurred following his return from Lausanne, where he had lived since 1783, and where nearly half his book was written. Except an autobiography, he wrote little worth mentioning beyond the history, but that amply sufficed to give him immortality.

Giotto, di Bondone
b. near Florence, 1276. d. Florence, Jan. 8, 1337.

His genius for art betrayed itself while he was a boy tending sheep. A generous patron, seeing him sketching upon a stone, had him properly instructed, and he became the head of a famous Florentine school of painting. Many fine specimens of his work remain. He designed the Campanile at Florence.

Gladstone, William Ewart
b. Liverpool, Dec. 29, 1809. d. Hawarden, May 19, 1898

The fourth son of Sir John Gladstone, Bart., a Liverpool merchant of Scottish descent, he was educated at Eton and Oxford, and entered Parliament, representing Newark as "a rising hope of the stern, unbending Tories," as Macaulay said

He held minor offices under Peel in the Administrations of 1834 and 1841, and though he was out of Parliament when the Corn Laws were abolished, he had a great share in preparing the measure which Peel passed. From this time he gradually drifted away from Tory traditions; and after he had raised the questions as to the condition of Greece and of the Neapolitan prisons, a speech of his caused the rejection of Disraeli's Budget of 1852. This led to Gladstone's being made Chancellor of the Exchequer in the Coalition Government which followed. Now and later he showed that genius for finance which made him the greatest Chancellor of our own day. He abolished many vexatious taxes, among them that on paper. Over the Crimean War and the Civil War in America his attitude excited criticism, and he lost his seat at Oxford University, for which he had sat eighteen years. South Lancashire elected him, and, Palmerston dying, Gladstone became Leader of the House of Commons and Chancellor of the Exchequer. His Franchise Bill unexpectedly caused the overthrow of his party, which, however, at the next General Election, gained a great majority, and made him Prime Minister. To take his seat, he had to be elected for Greenwich, South Lancashire having rejected him. The Irish Church was disestablished, the Education Bill of 1870 passed, and the Ballot Bill made law. The elections of 1874 were adverse to Gladstone, and Disraeli became Premier, whereupon the Liberal leader retired temporarily into private life, to be recalled by the Bulgarian massacres and his complete disagreement with Disraeli's foreign and domestic policy. Midlothian returned him as its member in March, 1880, and for that division he sat until the end. He again took office as Premier, and five very troubled years followed. Crime in Ireland, the Bradlaugh incident, affairs in Egypt and the Soudan, and the whole foreign policy of the Government, tended to make the period one of the most exciting and exacting of the century. Again the verdict at the polls was in his favour, but his Government lasted only a brief time, Home Rule causing a serious cleavage, and sending the Liberal party into exile for the next six years. In 1892 the country for the last time gave Gladstone a majority, and he passed his Home Rule Bill through the Commons for the House of Lords to reject it. Then he retired, compelled by failing sight and hearing to withdraw from the scene in which for over three score years he had been a principal and splendid figure. He was a man of intense enthusiasms, lofty ideals, untiring industry, one of the greatest orators and debaters this country has produced, and a writer of the first rank upon poetry and classical and theological subjects.

Gluck, Christoph Willibald

b. Weidenwang, Bavaria, July 2, 1714. d. Vienna, Nov. 15, 1787.

He was the son of a forest keeper in a princely household, and from his cradle showed musical talent. After study and teaching at Prague, Vienna, and Milan, he came to London, as composer of operas for the Haymarket. Here he was enabled to study Handel, and this led to his reaching his highest work. Returning to Vienna, he became the music-master of Marie Antoinette, who materially assisted him in the production of the operas which have made him famous wherever music is sung or played.

Goethe, Johann Wolfgang

b. Frankfort-on-the-Main, Aug. 28, 1749. d. Weimar, March 22, 1832.

Another example of a career turning out differently from parents' designs, Goethe was intended by his father to follow the law, and did actually practise, but literature had always the stronger appeal. A love affair--one of many which are reflected in his poems--inspired the first production, a little pastoral drama. Once begun, there was no end to the flow. Poems, plays, scientific and philosophical writings, even novels, streamed from his fertile brain. In 1775 he was invited by the young Duke Karl August to make his home at Weimar, and there he lived to the end of his days, except when he accompanied his patron, who went forth to fight the French. Goethe was an able statesman, and performed service of note for Weimar. One of his many love affairs led to an association with a beautiful girl of humble birth, whom he eventually married.

Goldsmith, Oliver

b. Pallas, Ireland, Nov. 10, 1728. d. London, April 4, 1774.

Good results have seldom been won from more unpromising material than in Goldsmith's case. The son of an Irish curate, he spent his youth unworthily. With no sense of the value of money, he gambled away the little which should have carried him to America, ran away from college, was rejected on seeking to take Orders, continued his dissipation in Edinburgh and on the Continent, and reached London well-nigh penniless. Here he passed a wretched existence as chemist's assistant, as hack-writer and proof-reader, and as usher. Better times dawned with the production of his essay on the condition of learning in Europe—written to raise funds to enable him to leave the country. Thought of emigration abandoned, he wrote, sandwiched between hack-work, his delightful poems, his immortal novel "The Vicar of Wakefield," and his drama "She Stoops to Conquer." He was improvident to the last, and died owing two thousand pounds. A genius of a high order, he was erratic and unstable.

Gounod, Charles François

b. Paris, June 17, 1818. d. St. Cloud, Oct. 18, 1893.

Son of a painter of no little ability, his talent for music early asserted itself, enabling him to carry off the Grand Prix de Rome before he was twenty-one. His stay in Rome gave him an insight into sacred music, which was to serve him later in life. When he returned to Paris, he tried in vain to find a publisher for some songs which he had written, so accepted a post as church organist, and made up his mind to take Orders. Instead of carrying out this plan, he was persuaded to write an opera. "Sappho" was the result, satisfactory if not brilliant. No commanding success was won until he took Goethe's "Faust" for a subject. That proved the greatest success in French music of the latter half of the nineteenth century. "Romeo and Juliet," his next best work, appealed as strongly to him, but he felt older when he wrote this. The Franco-Prussian War drove him to London, where he wrote a composition for the opening of the Albert Hall, and some songs, of which "Maid of Athens" is best known. Upon his return to Paris he composed operas, and then turned to sacred music. "The Redemption," dedicated to Queen Victoria, is the effort in this direction most esteemed in this country. He was a man of tireless activity, with innumerable works to his credit, but he will be best remembered by those mentioned.

Gray, Elisha

b. Barnesville, Ohio, Aug. 2, 1835.

No history of the telephone is complete which fails to place the name of Gray in the forefront. He claims, indeed, to be the inventor of the instrument. His title to fame, however, does not rest on ground so well occupied, for he has taken out scores of patents in relation to electrical appliances mainly concerned with telegraphy and telephony.

Gray, Thomas

b. London, Dec. 26, 1716. d. Cambridge, July 30, 1771.

Associated as a boy at Eton with Horace Walpole, he accompanied the latter on the "grand tour," but quarrelled and parted from him, and

went to Cambridge, and there had his residence, except for holidays spent with his mother at Stoke Pogos. After refusing the Poet Laureateship, he became professor of modern history at Cambridge. His best-loved poem is the "Elegy Written in a Country Churchyard," one of the most perfect gems in the language; next, the "Ode on a Distant Prospect of Eton College." His most ambitious work is "Progress of Poesy," a noble composition. He lived a life of quiet days, was never married, and was one of the most painstaking poets of any time.

Green, John Richard
b. Oxford, Dec. 12, 1837. d. Mentone, March 7, 1883.
Readers of "Robert Elsmere" will recognise Green in the hero of that novel. He was educated at Oxford, and entered the Church of England, but—partly through ill-health, partly through failing sympathy with its doctrines—he relinquished his association with the Church, and devoted himself to literature. His "Short History of the English People" had an unprecedented success, and is the introduction of practically all students into the history of our country. This, like his larger schemes, was written while he suffered terribly from ill-health. He was greatly beloved by a wide circle of friends, and the story of his long battle against suffering and incurable disease is an object-lesson by which all may profit.

Gregory XIII.
b. Bologna, Italy, Feb. 7, 1502. d. Rome, April 10, 1585.
He was a professor of law for many years before distinguishing himself as one of the theologians at the Council of Trent. Elected Pope when seventy years of age, he made his pontificate memorable by imposing upon Catholic Europe the Gregorian calendar. No revision having been made since the days of Julius Cæsar, there had arisen a discrepancy of ten days. He caused ten days to be eliminated from the month of October, 1582, and modified the plan as to leap years. It took nearly two centuries to get the reform accepted in England, but in the end there was no alternative to the adoption of the Gregorian calendar. Gregory was an enlightened Pope, and spent an enormous sum of money in promoting education. The one blot upon his career was his ordering a "Te Deum" in Rome upon the occasion of the St. Bartholomew massacres. That, however, may have been the outcome of the massacres being represented to him as the suppression of a Huguenot plot and rising.

Gresham, Sir Thomas
b. London, about 1519. d. London, Nov. 21, 1579.
The son of a prosperous Norfolk merchant, Gresham made a fortune in financial operations, and displayed such unselfish patriotism as to effect a salutary influence for good upon the national credit. Towards the end of his life he founded the Royal Exchange, Gresham College, and a number of almshouses.

Grimm, Jacob Ludwig Karl
b. Hanau, Germany, Jan. 4, 1785. d. Berlin, Sept. 20, 1863.
It is as part-author, with his brother Wilhelm, of the delightful fairy stories for children that Jacob Grimm is famous throughout Christendom; but his reputation is based upon higher ground. He was one of the most accomplished philologists ever produced by Germany, and his great dictionary and German grammar are among the most notable of that class of work in existence. He is the father of comparative Germanic philology. Like his brother, he studied law at Marburg, and together they shared the duties of librarian to their patron, the King of Westphalia, and simultaneously filled professorial chairs at Göttingen.

Grote, George
b. Beckenham, Kent, Nov. 17, 1794. d. London, June 18, 1871.
The author of the monumental history of Greece spent thirty-two years of his life in the bank which his grandfather had founded, and of which he eventually became the head. He sat for some years in Parliament, and was an earnest advocate of electoral reform. In addition to the famous history, he wrote an exhaustive work on "Plato and the Other Companions of Socrates," and was engaged up to the time of his death upon a volume on "Aristotle."

Grotius, Hugo
b. Delft, Holland, April 10, 1583. d. Rostock, Germany, Aug. 28, 1645.
From his youth up a diligent student of law, Grotius was early initiated into diplomacy, and turned his attention to the study of International law, of which he may be said to have been the father. His works upon the subject were for long the standard authority. Theological conflict caused his expulsion from the Netherlands, and he found sanctuary in Paris, to which he was subsequently sent as Ambassador for Sweden. He died while on a return journey from Stockholm. Although law was his absorbing study, he was also a gifted poet, a sound historian, and a statesman of rare ability.

Grove, Sir George
b. Clapham, Aug. 13, 1820. d. Sydenham, May 28, 1900.
In early life an engineer, Grove erected the first two cast-iron lighthouses in the West Indies, and assisted in the construction of the Britannia tubular bridge. An extraordinarily versatile man, he became secretary of the Society of Arts, edited a famous magazine, edited and partly wrote the admirable Dictionary of Music and Musicians to which he gave his name, and acted as a director of the Royal Academy of Music.

Grove, Sir William Robert
b. Swansea, July 14, 1811. d. London, Aug. 1, 1896.
As distinguished for versatility as his namesake, he was famous first as a lawyer, then as a judge of the Court of Common Pleas, and, chiefly, as a great physicist. He invented the Grove voltaic battery, and greatly advanced the whole science of electricity and optics, as well by his lectures from the chair of Natural Science at the London Institution as by his books.

Guericke, Otto von
b. Magdeburg, Prussia, Nov. 20, 1602. d. Hamburg, May 11, 1686.
After a long course of study at the best Continental universities, and visiting France and England, he became engineer-in-chief in the Swedish army. Civic appointments allowed him to devote his attention to experiments, with the result that he invented the first air-pump, and fashioned the famous "Magdeburg hemispheres," which, being deprived of air, were not pulled asunder until the united strength of fifteen horses had been employed. He invented also the air-balance, and made important discoveries in electricity.

Guido d'Arezzo
b. near Paris, about 990. d. Arezzo (?), near Paris, about 1050.
It is not quite accurate to say that Guido d'Arezzo invented the notation of music, but it is indisputable that he first devised—or, at any rate, first systematically employed—the lines of the staff and the intervals between them. The importance of this advance from the chaotic conditions previously existing can hardly be overstated. He seems to have invented the F clef. Undoubtedly he gave their names to the first six notes of the scale—ut, re, mi, fa, sol, la—these being the first syllables of six lines of a hymn addressed to John the Baptist. It was Guido's boast that by his system a pupil could learn more music in five months than by previous methods he could learn in ten years. Pope John XIX. was one of his most notable and successful pupils. The reformer was a monk, and, like most other reformers, persecuted by his contemporaries.

Gurney, Sir Goldsworthy

b. Treator, Cornwall, Feb. 14, 1793. d. Reeds, Cornwall, Feb. 28, 1875.

Trevithick's experiments with the steam-engine inspired young Gurney to efforts in the same direction. The result was his steam-carriage, which, in July, 1829, ran from London to Bath and back again on the open road at the rate of fifteen miles an hour, the first vehicle driven by steam to accomplish such a journey. The success of the enterprise was immediately nullified by Parliament, which, carried away by stupidity and folly, passed laws imposing prohibitive tolls. Gurney's steam-jet, however, was very successful. It was employed by George Stephenson for his famous "Rocket," and raised its speed from twelve miles to twenty-nine miles per hour. It was successfully applied, too, to steamboats and furnaces, and had a great influence in the manufacture of iron. The so-called "Drummond light" was Gurney's invention; so was the oxyhydrogen blowpipe. In his Royal Institution lectures, where he had Faraday among his listeners, he anticipated the principle of the telegraph. He lighted and ventilated the Houses of Parliament, invented a gaslight derivable from oil, and in many ways showed himself one of the great master minds of his age. His work in connection with lighthouses was specially important.

Gustavus Adolphus

b. Stockholm, Dec. 19, 1594. d. near Leipzig, Nov. 16, 1632.

Upon succeeding to the throne of Sweden, Gustavus found upon his hands wars with Denmark, Russia, and Poland. Girt about by enemies, torn by internal dissensions, with the kingdom weakened by the loss of territory, Sweden seemed in hopeless case. Gustavus was her saviour. He had been trained to statecraft; he showed now that he was a born warrior and leader of men. He healed the feuds by which his kingdom was rent; he fired his nobles with patriotism; he encouraged commerce and learning, and gave Sweden a new spirit. Peace was concluded with Denmark; Russia was compelled to relinquish to Sweden her Baltic provinces of Livonia, Esthonia, and Courland; Poland agreed upon a six years' truce. Then came work of wider character. Austria, crushing German Protestantism, was rapidly making herself supreme, and threatening both France and Sweden. Richelieu agreed to subsidise Gustavus, and with fifteen thousand men he took the field against this gigantic foe. It was expected that this little force would be laughed off the field of battle, but it proved an army the like of which Europe had not previously known. Every man felt himself a Protestant champion. Each day was begun with prayer: it ended with prayer. The army was perfectly disciplined. It was terrible in battle, humane in victory, considerate for the people in whose country its war was waged. With readier co-operation from the people whom he had come to help, Gustavus would have swept all before him, and probably have become Emperor of Germany, saving the land from the terrible evils which threw her back a century in the march of civilisation. As it was, he was everywhere successful, but tardy support prevented his conducting operations upon a greater scale, and so permitted the atrocities of Tilly and Wallenstein. It was in battle with the latter that he fell, and his troops avenged him by winning a great victory in one of the bloodiest battles ever fought. Gustavus was one of the greatest characters in history—a scholar, an enlightened ruler, with pure and lofty purpose, and a soldier of the very highest order.

Gutenberg, Johann

b. Mainz, about 1400. d. Mainz, Feb. 2, 1468.

His father's name was Gänsfleisch, but he took his mother's maiden name, and suffered with his family when the patricians, of whom he was one, were driven by the common people from Mainz. From the cradle he seems to have shown mechanical ingenuity, and had a project in his youth for polishing stones and making mirrors. This project not succeeding, he turned his attention to printing, and was, the Germans say, the first man to invent metal type and print a book. There is some doubt as to whether the idea actually originated with him. Pictures had been printed from engraved blocks. Gutenberg's departure, however, was the first attempt at making a book independently of the pen. A man named Dritzehn and the two brothers Heilmann were his partners in the enterprise; and there was Peter Schöffer, an expert metal-worker, who made the metal types. These names occur in the controversy; while there is the legend that the first types were stolen from their inventor, Laurens Janszoon Coster, and taken to Gutenberg. After examination of all the evidence, however, German scholars credit Gutenberg with the invention. The first book produced was a Latin Bible, which appeared in August, 1455, twenty-two years before the first book printed in England made its appearance. The invention spread rapidly to other German towns, but Gutenberg did not profit. A money-lender named John Fust, who had financed him, seized his types, and he was compelled to work with inferior metals. So poor was he that he was glad to take a Court appointment, which brought him each year one suit of raiment and an allowance of food. He died in poverty and misery, though he had given to the world an art which makes it for ever grateful to his memory. Gutenberg is finely celebrated by Victor Hugo in the following passage: "A Gutenberg discovering the method for sowing the seed of civilisation and the means for the ubiquity of thought will be followed by a Christopher Columbus discovering a new field. A Christopher Columbus discovering a world will be followed by a Luther discovering a liberty. After Luther, innovator in the dogma, will come Shakespeare, innovator in art. One genius completes the other."

Guthrie, Thomas

b. Brechin, Forfarshire, July 12, 1803. d. St. Leonards, Feb. 24, 1873.

An eminent orator and philanthropist, he helped to found the Scottish Free Church, for which he raised £116,000 in eleven months, and by his writings led to the building of the first Ragged School. He was also remarkable as an advocate of temperance and compulsory education.

Guy, Thomas

b. Southwark, about 1644. d. London, Dec. 27, 1724.

The son of a London lighterman, he was apprenticed to a bookseller, set up shop himself as another, printed Bibles and Prayer-books from type imported from Holland, made much money by buying sailors' pay-tickets at a huge discount, and still more from the dealing in South Sea stock. Of this he had invested £45,000 in £100 shares, which he sold in time to avoid the crash at prices varying between £300 and £600 per share. He is commonly reputed to have been mean and avaricious, but this legend does not bear examination. During his life he established almshouses at Tamworth, and built there a town-hall. He paid the debts of innumerable people confined in the prisons of the City, and set up many deserving young men in business. He added three new wards to St. Thomas's Hospital, and built the hospital which bears his name. His will, a remarkable document, liberated six hundred persons from the debtors' prisons, and made provision for a great number of relatives and persons not related to him, provided almshouses and pensions and many other benefits. He never married, lived simply, dressed simply, and thus, it is probable, got the reputation for avarice and miserliness.

Hadley, John

b. London, April 16, 1682. d. London, Feb. 14, 1744.

By his improvement of the telescope, left imperfect by Newton and Gregory, he gave astronomers the first instrument of that kind which

was of real value to them. He also made important improvements in the invention of the reflecting quadrant, which rapidly became indispensable at sea. Hadley's younger brother George, a scientific writer (1685-1786), had his share of the family talent, and was the first man clearly to formulate the correct theory as to the trade winds. The genius of the family was not transmitted beyond this generation, for John Hadley's son, inheriting an ample fortune in money and real estate, squandered it, and died in poverty and disgrace.

Hadrian, Publius Ælius Hadrianus
b. Rome, Jan. 24, 76 A.D. d. Baiae, Italy, July 10, 138 A.D.

When forty-one years of age, Hadrian succeeded his guardian and cousin Trajan and at once inaugurated a new and beneficent policy. He realised that the era of conquest had passed, that Rome must now be wisely governed, and the Empire secured rather than indefinitely extended. Determined personally to know the needs of the Empire and its people, he undertook a journey throughout the entire dominions of Rome. Wherever he went architects and artisans accompanied him, organised like a legion, to build aqueducts, temples, fortifications, whatever he deemed necessary. The magnitude of his scheme may be estimated from the great wall bearing his name which he constructed, upon visiting Britain, from the Solway to the Tyne. Its purpose was to serve as a defence against the Picts and Scots. Seventy-three miles in length, it was in places more than twelve feet in height, and between six feet and nine and a half feet thick, and included for the accommodation of troops, stations, castles and turrets, which communicated with one another by a military way. Although no more conquests were to be attempted, his army was maintained in the highest state of efficiency. That the soldiers should not complain of the rigorous discipline which he imposed, he himself shared their hardships. He lived on the food which they had, and walked his twenty miles a day bareheaded. His laws were merciful and wise, and Rome flourished greatly under his rule. Towards the end of his life his mind seems to have weakened and to have become overcast with jealousies and littlenesses. His character was stained with bloody crimes. The one great war of his reign was waged against the Jews, of whom it was said over half a million were slain, while the Roman losses also were appalling.

Hahnemann, Samuel Christian Friedrich
b. Meissen, Saxony, April 10, 1755. d. Paris, July 2, 1843.

After studying medicine at Leipzig and Vienna, and taking his degree at Erlangen, he became convinced that old methods were wrong. The result of his investigations led to his founding the homœopathic system of medicine. The new treatment was vigorously denounced, and he was boycotted by his profession, but he courageously adhered to his work, submitted to pecuniary loss for his faith, and, moreover, made many painful experiments upon his own person for the furthering of the system which he had founded.

Haeckel, Ernst Heinrich
b. Potsdam, Germany, Feb. 16, 1834.

This distinguished German biologist was entering upon his scientific course when Darwin's "Origin of Species" made its appearance. That book determined Haeckel's career. He read it, accepted its teaching, and by his enthusiastic advocacy made the doctrine known throughout Germany. Since then Haeckel has engaged in research work of the highest value, and contributed greatly to the common stock of knowledge upon biological mysteries. Latterly he has formulated theories which Christian students of science cannot accept.

Haggard, Henry Rider
b. Bradenham Hall, Norfolk, June 22, 1856.

One of a distinguished brotherhood, he went to Natal as secretary to Sir Henry Bulwer; passed on, as secretary to Sir Theophilus Shepstone, to the Transvaal, where he hoisted the British flag at Pretoria. Afterwards returning to England, he wrote a number of successful imaginative novels. Latterly he has been engaged in investigations concerning the conditions of rural England, and has carried out important inquiries on behalf of the Government in connection with emigration schemes to the Colonies.

Hakluyt, Richard
b. Herefordshire, about 1552. d. London, Nov. 23, 1616.

The author of what has been termed "the prose epic of the modern English nation" was a Westminster scholar, and graduated at Christ Church, Oxford. His absorbing study was the history of travel and discovery, whether in Greek, Latin, Italian, Spanish, Portuguese, French, or English. He lectured on his favourite subject, and had the gratification of introducing the globes into English schools. Then he wrote an account of the discovery of America, and so gained the patronage of Lord Howard of Effingham, who took him to Paris. There he pursued with all diligence his special study, and, piqued to find Englishmen regarded as of no account in the story of discovery and adventure, he consecrated his life to writing his immortal history of the voyages, adventures, and discoveries of our national heroes. For some years before his death he was Archdeacon of Westminster, and one of the chaplains of the Savoy.

Hales, Stephen
b. Bekesbourne, Kent, Sept. 7, 1677. d. Teddington, Middlesex, Jan. 4, 1761

Although little is heard nowadays of his works, Hales was a man far in advance of his times. Upon his "Vegetable Statics" is founded our whole knowledge of vegetable physiology. He invented the artificial ventilator, and got it introduced into prisons, ships, and other buildings. He had a scheme for preserving water and meat on sea voyages, and for distilling drinkable water from the sea; and a method of registering sea depths which were by ordinary means unfathomable. Hales was a clergyman, and resided for many years in charge at Teddington. He provided a new water supply, and his entry concerning the new supply is characteristic of the minuteness with which his investigations were carried out. The outflow was such that it would fill a half gallon vessel in "three swings of a pendulum, beating seconds, which pendulum was 39 2-10th inches long from the suspending nail to the middle of the plumbet or bob."

Halifax, Charles Montagu, Earl of
b. Horton, Northants, April 16, 1661. d. London, May 19, 1715.

Statesman, poet, munificent patron of literature, friend of Newton, Addison, Congreve, Prior, and Swift, Charles Montagu is best remembered for his achievements in the House of Commons. A million of money being needed for government, he established the National Debt. A further million and a quarter being necessary, he established the Bank of England—a plan originated, by the way, three years earlier by William Patterson. He made Newton Warden of the Mint, and with his help, and that of Somers, Locke, and Halley, reformed the currency. Exchequer bills, by which the Government gets its first credit from the House of Commons, also had their origin with Montagu. His vanity and arrogance made him unpopular, and he had to take a peerage and depart to the Upper House. Two attempts to impeach him for misconduct of public affairs came to nothing. He was a grandson of the Earl of Manchester, the Parliamentary general.

Hall, Sir James
b. Dunglass, Haddingtonshire, 1761. d. Edinburgh, June 23, 1832

He was the father of three distinguished sons. John, the eldest, became a Fellow of the Royal Society; Basil, traveller and writer, made important discoveries in the Eastern seas; James was a talented artist and patron of art. Sir James's own claim to fame rests upon his having been the first geologist to embark upon experimental

geology. Hutton protested that it was impossible to judge of the great operations of the mineral kingdom from having kindled a fire and looked into the bottom of a little crucible. But time justified the chemical tests of the baronet, and it was in his laboratory that experimental geology, from which we have learned so much, had its birth. He was the inventor of an instrument for registering high temperatures.

Hallam, Henry
b. Windsor, July 9, 1777. d. Penshurst, Kent, Jan. 21, 1859.

The son of a Canon of Windsor and Dean of Bristol, he took his degree at Oxford, and then held the post of Commissioner of Stamps. Upon inheriting his father's fortune, he devoted himself to literature, and by his "Europe During the Middle Ages," his "Constitutional History," and his "Introduction to the Literature of Europe," placed himself in the very front rank of historians. He is severe, but accurate; austere, but learned and judicious. Arthur Henry Hallam, of Tennyson's "In Memoriam," was one of his eleven children, of whom only four survived to cheer his old age.

Haller, Albrecht von
b. Bern, Switzerland, Oct. 16, 1708. d. Bern, Dec. 12, 1777.

Here the boy was truly father of the man. Before he was ten he had drawn up a Chaldee grammar and a Greek and Hebrew vocabulary, and compiled a great collection of biographies. He risked his life to rescue from fire his translations of the classics, and afterwards burned them. After a course of study at the best universities, he rapidly qualified to rank as one of the greatest anatomists and physiologists of his century. He filled the chair of medicine, anatomy, botany, and surgery in the new University of Gottingen, and attained a European reputation by his industry, his original researches, and his success as the leader of a new school of learning.

Halley, Edmund
b. Haggerston, London, Nov. 8, 1656 d. Greenwich, Jan. 14, 1742.

The great astronomer was the son of a rich soap-boiler, who gave him an excellent education, and when sending him to Oxford presented him with a large telescope. Before he had reached manhood, Halley devised a new method of determining the elements of the planetary orbits; he then resolved to catalogue the stars in the Southern Hemisphere by way of complementing the efforts of Flamsteed and Hevelius in the Northern Hemisphere. During his stay at St. Helena, he observed a transit of Mercury across the sun's disc, and by so doing arrived at his method of ascertaining the solar distance. His successful charting of 360 stars and his other important discoveries led to his being termed the "Southern Tycho." Honours and more notable labours followed, and then his inquiries into gravity brought him into association with Newton, whose "Principia" he published at his own cost when, at Halley's earnest solicitation, Newton had written it. Halley's other work, undertaken with a view to solving problems as to the variation of the compass, the discovery of Southern lands, and his observations enabling him to predict the return of the comet named after him, was all-important and valuable as opening new horizons for the men who were to follow after.

Hamilcar, Barca
b. Carthage, North Africa, about 260 B.C. d. Spain, 228 B.C.

"Barca," his surname, is the Jewish term for "lightning," and refers to the character of the military operations of this great warrior and statesman. In his day, Carthage was the great rival of Rome, and had colonies in Sicily, Corsica, and Sardinia. Hamilcar died in the attempt to add Spain to the Carthaginian possessions and to make it a centre for an attack upon Rome. In the first Punic war he landed in Sicily with a small army, at first little better than savages, but afterwards moulded by his will into a magnificent fighting force. He maintained himself for three years on Mounte Erete against the Romans, who for the whole time were in possession of the rest of the island, save for two additional strongholds which he held but they blockaded. To raise the blockade, he moved to what is now Mount St. Giuliano, and there for two years withstood the onslaughts of the Romans. At length overwhelming numbers defeated him, and brought to an end the first Punic war. Returning with his army to Africa, he was unable to obtain the pay for his soldiers, and was called upon to subdue a formidable insurrection. This accomplished, he became commander of all the Carthaginian forces, and, having sworn his eldest son, Hannibal, to eternal hatred and enmity to Rome, he set out with a picked force for Spain. Some parts of the country he subdued by force of arms; other parts he won to allegiance by statesmanship. He died, however, before he could complete his plans, slain in a battle between the Tagus and the Douro. His son Hannibal carried on his task.

Hamilton, Sir William Rowan
b. Dublin, Aug. 4, 1805. d. Dunsink, near Dublin, Sept. 2, 1865.

He was a phenomenal boy, could speak thirteen languages by the time he was twelve, had mastered all the ordinary University course at fifteen, and entered upon original research. He distinguished himself in astronomy, acting as Irish Astronomer Royal, but is specially celebrated as the inventor of quaternions, a calculus of peculiar power and generality.

Hampden, John
b. London, 1594 d. Thame, Oxfordshire, June 24, 1643.

A cousin of Oliver Cromwell, and a member of a distinguished old Buckinghamshire family, Hampden came into prominence in Parliament by his resistance of the loan which Charles I. attempted unconstitutionally to raise. He was conspicuous in the impeachment of Buckingham and Strafford. It was his resistance of the Royal demand for ship-money, however, which made him a national figure. He undertook the expense of fighting the case, and though seven of the twelve judges decided against him, the patriot had the sympathy and approval of all right-thinking men in the country. Hampden was one of the five members whom Charles I. sought to arrest in the House of Commons. That act brought on the Civil War. Here Hampden, who subscribed £2,000, and took an active part in the campaign of the Parliamentarians, showed courage and ability. He died from the effects of a bullet-wound sustained while attempting to counter a foray of Prince Rupert from Oxford. Hampden was a great patriot, and a noble Christian gentleman.

Handel, George Frederick
b. Halle, Germany, Feb. 23, 1685. d. London, April 14, 1759

The son of a Halle surgeon, he was regarded, almost from infancy, as a musical prodigy, and was given the best musical education his father could afford. Before he was twenty he had written and produced his first opera. He played in a Hamburg orchestra, gave lessons, wrote minor pieces, and then made a triumphal progress through Italy. Returning to Hanover, he was made Chapelmaster to the Elector, our own George I. It was in 1710, when he was five-and-twenty, that he came to England, which from that time became his home. Ten years later the Royal Academy was founded, "to secure a constant supply of operas by Handel." That scheme did not long flourish. Handel wrote opera after opera, but quarrels with rivals and with his singers brought him eventually to bankruptcy, and for the time being unhinged his mind. It was upon his recovery that he began what was to be the work of his life—his oratorios. Fifteen of them he produced in a dozen years. His sight, long failing, now deserted him, but he still continued to compose and to give his magnificent organ recitals. Altogether, he wrote a score of oratorios, twice as many operas, hundreds of cantatas, psalms, songs,

and instrumental pieces. His industry was inexhaustible, his fertility so phenomenal that some of his greatest works are said almost to have been improvised. He treated all styles, and he excelled in all. No man ever more richly dowered the world with sublime, inspiring melody.

Hannibal
b. Carthage, North Africa, 247 B.C. d. Bithynia, Asia Minor, about 183 B.C.

When nine years of age, Hannibal, eldest of the "lion brood" of Hamilcar, the great general, was compelled by his father to swear on the altar of sacrifice a vow of eternal enmity to Rome. He was then permitted to accompany his father from Carthage to Spain. At the death of Hamilcar, the command evolved upon his brother-in-law, but Hannibal became supreme, and proceeded to give effect to that part of Hamilcar's plan which death had caused to be left unfinished. He completed the conquest of Spain, all save one stronghold – Saguntum, which was in friendly relations with Rome. By attacking and reducing this he made all Spain a Carthaginian province, and brought on the second Punic war. With an army which finally dwindled down to 40,000 infantry, 6,000 cavalry, and fewer than two score elephants, he crossed first the Pyrenees and then the Alps, a daring, grandiose scheme, which only the greatest soldier of all time could have carried through. It was a war for the conquest of the world in which he was now engaged a world ruled by Carthage or Rome. In battle after battle he inflicted appalling losses upon the Roman armies ... never knew defeat in all the sixteen years in which he overran Italy. Reinforcements which were being sent to him from Spain were cut off. He was recalled to defend Carthage from a Roman invasion, and at last Scipio won a decisive triumph over him. Hannibal's veterans, outnumbered, were cut to pieces; his raw levies fled. Carthage was already conquered before Hannibal appeared upon the scene; his small army could not avert the ruin. He now turned his genius to statesmanship, but his enemies caused him to flee, first to Antiochus of Syria, next to Bithynia, where, still pursued by the vindictive Romans, he took poison. Hannibal has been called at once the Burke, the Pitt, and the Wellington of his country. He was a great statesman, and the finest general in history. He only just failed to make Carthage mistress of the whole world.

Hansom, Joseph Aloysius
b. York, Oct. 26, 1803. d. London, June 29, 1882.

The inventor of the cab, which still retains his name, was apprenticed to his father, a carpenter, but showed great skill as a draughtsman. He attended a night school, improved his scanty education, and became a famous architect. His churches, mostly Roman Catholic, are to be seen in many parts of England, and even in Australia and South America. His church at Preston St. Walburge's has a spire 306ft. high, the loftiest built in England since the Reformation.

Hanway, Jonas
b. Portsmouth, Aug. 12, 1712. d. London, Sept. 5, 1786.

Left fatherless at an early age, he was apprenticed to a Lisbon merchant, and became a great traveller for commercial purposes. Inheriting a small competence, he devoted the remainder of his life to social and philanthropic work to such schemes as the paving of London, the care of foundling children, of sweeps' boys, and outcast women, prison reform, and the establishment of Sunday-schools. He was the first Englishman to carry an umbrella, and after thirty years of derision saw his invention generally popular.

Hardy, Thomas
b. near Manchester, Dorsetshire, June 2, 1840.

The novelist and poet of Wessex scenes and life began his career as an architect. "Far From the Madding Crowd" and later novels—notably, "The Return of the Native" and "Tess of the D'Urbervilles"—have given him a unique place among English artists in fiction. He writes with great imaginative power, tinged with pessimism. Latterly he has forsaken fiction for historical drama.

Hare, Robert
b. Philadelphia, Jan. 17, 1781. d. Philadelphia, May 15, 1858.

He was a famous chemist of his day, and added notably to the science in which he was interested. His material gift to the world was the calorimeter, an instrument for measuring the specific heat of a body. He invented also an oxyhydrogen blowpipe, but in that he had been anticipated by the English inventor, Sir Goldsworthy Gurney.

Hargraves, Edmund Hammond
b. Gosport, Hants, Oct. 7, 1816. d. Sydney, N.S.W., Oct. 29, 1891.

The man who was destined to discover the Australian goldfields went to Australia in 1832, and after narrowly escaping death settled down to sheep-farming for fifteen years. He joined in the rush to the Californian goldfields. Arrived there, his knowledge of geology told him that the geological formation was similar to that of the quartz rocks of the Blue Mountains, New South Wales. He returned to Australia, put his theory to the test, and at once found gold. His discovery was unselfishly communicated to the Government, and a new era for the island continent opened.

Hargreaves, James
b. Blackburn (?), about 1720. d. Nottingham, April, 1778.

The inventor of the spinning jenny was an illiterate weaver, who began life as a carpenter. His mechanical skill being detected by the grandfather of Sir Robert Peel, he was set to work to improve the carding machine. An accident the overturning of one of the old hand spinning-wheels – revealed to Hargreaves possibilities of a different system of construction, and he secretly made the spinning jenny, which would spin wool, cotton, or flax into a plurality of threads at the same time and by one operation. It was the first advance of the sort from the old plan of manual labour. When the invention became known, jealous workmen smashed the machine and demolished Hargreaves' house. Like Arkwright, he was driven to Nottingham. Here he entered into partnership with a man named James, and patented his machine. He seems to have made little out of it, Lancashire manufacturers pirating the invention, and leaving his family to poverty when he died.

Haroun-Al-Raschid
b. near Teheran, March 20, 763 (?), A.D. d. near Khorassan, Persia, 809 A.D.

The hero of so many stories in the "Arabian Nights" was the most famous of all Arabian califs, the most learned man of the then most learned people in the world. His dominions extended from Egypt to the Indus; his Court was the home of the most brilliant company of scholars, poets, grammarians, cadis, and scribes ever assembled round one calif. Ascending the throne when twenty-two years of age, he entrusted the Government to the famous Barmecide family, and saw to it that frontiers were strengthened, commerce developed, and learning encouraged. Five years before his own death, however, in an insane fit of jealousy, he had the Barmecides put to death. This was the one blot upon an otherwise noble character. As a warrior he overran Asia Minor at the head of a splendid army, and died while suppressing an insurrection at Khorassan. He several times made the pilgrimage to Mecca, and, despite the murder of the Barmecides, was renowned for humanity and chivalry. At the coronation of Charlemagne he sent, among other gifts, the keys of the Holy Sepulchre. Mediæval culture owed much to the intellectual splendours of the reign of "Aaron the Just," as he was called.

Harriot, Thomas
b. Oxford, 1560. d. Isleworth, Middlesex, July 2, 1621.

Having graduated at Oxford, he became mathematical tutor to Sir Walter Raleigh, through whose influence he was sent as surveyor with Sir Richard Grenville's expedition to Virginia. The result of his labours was the presentation of one

of the earliest examples of a statistical survey on a large scale. Harriot was one of the famous scientists who bore Henry Earl of Northumberland company during his imprisonment in the Tower. With Walter Warner and Thomas Hughes he used to go there daily, and dream and solve problems. He was warned that if he did not make his discoveries public he would be anticipated, and he was: Viète, the French mathematician, anticipated his publication of the discovery upon which modern algebra is based. Still, Harriot carried the subject further than his contemporary, and it is claimed for him that but for his foundation Descartes' whole superstructure would have been impossible. The Earl of Northumberland gave him a pension and quarters at Sion House, and there he died.

Harrison, Frederic
b. London, Oct. 18, 1831.

After a distinguished career at King's College School, London, and at Oxford, he was called to the Bar, and practised conveyancing and equity. It has been as a publicist and man of letters, however, that he has taken a foremost place. He has striven unceasingly for popular rights, and as the intellectual leader in England of the Positivists has laboured without remission to win converts to the doctrines of Auguste Comte. He has been Professor of Jurisprudence and International Law at Lincoln's Inn Hall, and served upon Royal Commissions.

Harrison, John
b. Foulby, Yorks, March 24, 1693. d. London, March 24, 1776.

The inventor of the chronometer was the son of a carpenter who knew a little about clock-making, and set his boy to walk in like paths. But the boy was a genius, though he had to dispense with the education of one. He made a clock all of wood, then one with his famous "gridiron" pendulum, which was so constructed that changes of temperature did not affect the timekeeping. At this time navigation was very much a haphazard matter, so the Government offered three prizes—£10,000, £15,000, and £20,000—for the discovery of a method of determining the longitude at sea within sixty, forty, and thirty geographical degrees respectively. Harrison, with nothing but native genius to help him—no education and no models to suggest a plan—devoted the best years of his life to the task. He made four timepieces, each better than its predecessor, until, after voyages to and from Jamaica, and to and from Barbados, it was found that he had determined the longitude within ten miles, or twenty miles better than the distance required to qualify him for the first prize. He was submitted to scandalous indignities, his money withheld, and petty sums offered by way of solatium. He was friendless, but he had earned the prize, and he persisted with petition after petition until eventually, little by little, he got the sum due to him. But it cost nearly a lifetime to obtain the money. The prize was offered in 1713; he won it in 1762; he got his money in 1773, when he was within less than three years of the grave.

Harvard, John
b. London, 1607. d. Charlestown, Mass., Sept. 14, 1638

The principal founder of the famous Harvard University was the son of a Southwark butcher. His mother was thrice married, and, deriving property from each husband, left John the Queen's Head public-house, Southwark. He graduated at Cambridge University, married, and went to America, where he officiated as minister at Charlestown. In his will he left £700 and a library of 320 books to the college then about to be built. It was called Harvard in his honour.

Harvey, William
b. Folkestone, Kent, April 1, 1578. d. London, June 3, 1657.

The discoverer of the circulation of the blood came of good old Kentish yeoman stock, and was given the advantage of a first-class education, not only in England, but in Italy, where the schools of medicine were already famous, and where he was privileged to hear Galileo and Fabricius of Aquapendente. The latter had already made known his discovery of valves in the veins, tending to a flow of the blood in a special direction. Many minds were concentrating on the problem as to the blood, and controversy afterwards raged as to whether or not Harvey really discovered the truth. He did. Other inquirers had got some glimmering of the truth, but they had inverted the facts. To Harvey alone is due the credit for demonstrating that the perpetual motion of the blood in a circle is produced by the beat of the heart. The grand discovery was announced quite informally in discourses before the College of Physicians in their lecture-hall at Knightrider Street, near St. Paul's, and the MSS. of the lectures are still preserved at the British Museum. For some years after his return from the continent, Harvey acted as physician to St. Bartholomew's Hospital, where he had a salary of £33 6s. 8d. per year and no residence. He was in favour at Court, being successively physician to James I. and Charles I. He accompanied the latter as medical attendant during the Civil War until the surrender at Oxford.

Haussman, George Eugène
b. Paris, March 27, 1809. d. Paris, Jan. 11, 1891.

To all who love Paris, with its noble boulevards, its open spaces, its many fine bridges, and its beautiful parks, Haussman is indeed a great man. It was he whom Napoleon III. entrusted with the making of the modern Paris, when, having thrown up the Bar, he entered the Civil Service. He carried out the whole work for water supply and sanitation, in addition to the embellishment of the entire capital. The work left Paris with a debt of thirty-five million pounds, and caused his dismissal. Turning bank director, and then being elected a deputy, he was still dogged by evil fortune, and died in poverty.

Hauy, René Just Abbé
b. St. Just, France, Feb. 28, 1743. d. Paris, June 3, 1822.

His parents were so poor that it was only through the charity of friends that he was educated. He underwent his course at college amid almost incredible privations and misery. The accidental fall of a treasured specimen of calcareous spar led him, on examining the fragments, to discover the geometrical law of crystallisation. He devoted his life to mineralogy with important results. He was given an honorary canonry at Notre Dame, hence he is generally spoken of as the Abbé Haüy. His brother Valentin—like himself, poor all his days—consecrated his life to the education of the blind poor.

Havelock, Sir Henry
b. near Sunderland, April 5, 1795. d. Lucknow, India, Nov. 24, 1857.

This great Christian soldier was the son of a wealthy shipbuilder, and was to have been a lawyer, but, like his three brothers, entered the Army. He went to India, where he was converted and publicly baptised. He had an active part in all the fighting of his time, and his crowning work was, during the Mutiny, to relieve Lucknow. There he died two months later, killed by work and worry and responsibility. When the tidings of his great feat reached England, Parliament voted him a baronetcy and a pension of £1,000 a year. But they were voting the reward to a man who, though they did not know it, was already in his grave.

Hawke, Edward, Lord
b. London, 1705. d. Sunbury, Middlesex, Oct. 17, 1781.

The son of a barrister, he took early to sea, and when thirty-nine was dismissed the Service for a too great success. He was in command of the Wolf, and broke from the line of battle at Toulon to engage and defeat a French ship. For this breach of discipline he was dismissed, but was restored as an act of Royal favour, and lived to defeat the French fleet which, under Admiral

De Conflans, was to have covered an invasion of England. He was raised to the peerage, and given a pension of £2,000 per annum.

Hawthorne, Nathaniel
b. Salem, Mass., July 4, 1804. d. Plymouth, U.S.A., May 19, 1864.

A dreaming, solitude-loving boy, Hawthorne, son of a merchant captain, was left much to his own resources from an early age, his father dying when he was four. The love of isolation never left him. He lived, as a boy of fourteen, at a lonely farm in the woods of Maine, and as a man he became one of the Brook Farm community, where, with one or two other men, he tried the experiment of running a farm on idyllic semi-socialistic lines. He shut himself up for a dozen years in complete seclusion before he gave the world his first novel—"Fanshawe." America would have none of his works, but his writing found immediate acceptance in England, where to the end his reputation was higher than in his own land. England, indeed, set the Hawthorne vogue. For many years his circumstances were not easy, and he had to take employment as weigher and gauger in a customs house, while afterwards he held a consular appointment for four years at Liverpool. His income grew in time, and he was able to travel Europe, and finally to end his days rich in this world's goods—and rich, too, in honour. His writings are simple but melodious, full of fine feeling and insight. His reputation is still increasing and will increase.

Hay, John
b. Salem, Ind., U.S.A., Oct. 8, 1838. d. July, 1905.

Having been called to the Bar, he became assistant private secretary to President Lincoln, of whom, in conjunction with another writer, he produced an excellent biography. Famous as a statesman of wisdom and high ideals, he is best loved as the author of the delightful poems "Pike County Ballads," of which "Breeches" suffices to ensure his immortality.

Haydn, Joseph
b. Rohrau, Austria, March 31, 1732. d. Vienna, May 31, 1809.

He was wretchedly poor, only a wheelwright's son, and when his term as a soprano in the choir of a Vienna church ended he had a hard fight for bare existence. But genius burned, and a man of discrimination hearing a composition of Haydn's played by the composer himself in the street, commissioned him to write an opera. Haydn seized his chance. His opera was a success. It brought him introductions to influential people, and finally got him a lucrative appointment. He had to come to England, however, before he was truly appreciated. Here, in two visits, he produced his twelve great symphonies. Thereafter he composed his magnificent oratorios. The importance of Haydn to the world has been thus impressively expressed by the Right Hon. A. J. Balfour: "Without Haydn we should not have the Mozart we know; without Mozart we should not have the Beethoven we know; and without Beethoven the whole musical history of the nineteenth century would have been utterly different from what it is."

Hazlitt, William
b. Maidstone, Kent, April 10, 1778. d. London, Sept. 18, 1830.

"Well, I've had a happy life," he said with his last breath. The statement does not quite accord with fact. He was twice unhappily married, and had a stupid love affair with a woman intellectually his inferior. But there was something lovable in the man who could command the friendship of Lamb, Leigh Hunt, and Coleridge. He quarrelled, where it was possible, with all his friends, but Lamb was loyal and true to the last. Hazlitt tried his hand at painting without success. His contributions to literature are unequal. At his best he is very fine, and his reputation has been greatly enhanced of recent years. He was a master of epigram and of virile, nervous English. His father was a Unitarian minister, and Hazlitt himself studied for the Church. His early meeting with Coleridge dissuaded him from his original intention, and turned his thoughts first to art and then to literature.

Heathcote, John
b. Duffield, near Derby, Aug 7, 1783. d. Tiverton, Devon, Jan. 18, 1861.

He was the son of a Leicestershire farmer, and was apprenticed first to a hosiery manufacturer, then to a stocking-maker and framesmith. His indentures completed, he worked as a machine-builder, and bought out the man by whom he had been employed at Nottingham. Then he turned his attention to the construction of a machine which would do for lace what the loom had done for stockings by superseding the knitting-needle. For his purpose he took himself to Hathern, a little town near Loughborough, and carefully worked out his scheme—first on paper, then expressed in material form. The outcome was that at twenty-four years of age he had perfected what was described as the most complicated machine ever produced. The first square yard of net made by the machine sold for five sovereigns, 240 times the price which it would now command. Here, then, was the origin of the enormous lace industry which has meant so many millions sterling to Midland England. Heathcote was not long permitted the quiet enjoyment of his reward. The Luddites demolished the machines which he had erected in his Nottingham factory, and he was awarded £10,000 by the country, but never got the money. He moved to Tiverton, set up new machinery, constantly added improvements, invented a steam plough, sat in Parliament, built schools, and died wealthy and honoured.

Heathfield, George Augustus Eliot, Lord
b. Stobs, Roxburghshire, Dec. 25, 1717. d. Aix-la-Chapelle, July 6, 1790

The gallant defender of Gibraltar was educated at Leyden University and the French military school of La Fère, as well as at Woolwich. He saw a great deal of fighting on the Continent before being sent to Gibraltar. He had some time in which to strengthen the defences of the fortress, but his defence for three years was one of the greatest achievements in the annals of war. Not only had he to withstand the combined assaults of fleet and army; the fortress was blockaded by sea and land, and the garrison was all but starved. While solicitous for the comfort of his men, he was himself of the simplest habits—a vegetarian, and total abstainer from alcohol. His peerage was granted in recognition of his valorous defence.

Heber, Reginald
b. Malpas, Cheshire, April 21, 1783. d. Trichinopoly, India, April 3, 1826.

After a distinguished career at Oxford, where his prize poem "Palestine" attained lasting fame, he accepted a country rectory in Shropshire, but was called to India as Bishop of Calcutta, and there died. His literary reputation rests upon his collection of hymns, of which "From Greenland's Icy Mountains," "The Son of God Goes Forth to War," and "Holy, Holy, Holy," are sung in every Christian land.

Hedley, William
b. Newburn, Newcastle, July 13, 1779. d. Lanchester, Durham, Jan. 9, 1843.

One of the pioneers of the age of steam, he has received less credit than he deserves. Working in a colliery, he perceived the need for better methods of hauling the coal from the pit-mouth to the Tyne, and, scorning the old toothed rails and cogged wheels with which locomotives were first invented, he devised and patented the smooth rail which we still use. He was among the first to use the steam blast for furnaces, and to apply steam for the purposes of barge propulsion.

Hegel, George Wilhelm Friedrich
b. Stuttgart, Germany, Aug. 27, 1770. d. Berlin, Nov. 14, 1831.

Destined by his parents for the Church, Hegel preferred the career first of tutor, and afterwards of professor. In the latter capacity he drew crowds of students to Heidelberg, and, later, to Berlin, and became the philosophical dictator of Germany. He established two different schools of thought. One of these interpreted his philosophy as true Christian theism; the other, as a pantheistic and

eventually materialistic direction, denying both the personality of God and the immortality of the soul.

Heine, Heinrich
b. Dusseldorf, Prussia, Dec. 13, 1799. d. Paris, Feb. 17, 1856.

Poetry was to Heine a "holy plaything." His writings on religion, philosophy, and politics were often merely vehicles for his wit and cynicism. Yet their revolutionary character made his native Germany no place for him, and he spent the last twenty-five years of his life in Paris, drawn thither by the Revolution of 1831. By that time he had established his fame upon a firm foundation with his "Buch der Lieder" and "Reisebilder." These caused him to be hailed as the successor of Goethe. But born a Jew, and compelled to become a member of the Lutheran Church in order that he might practise law in accordance with the terms upon which he drew an allowance from a wealthy uncle, he became very unpopular with his compatriots. His best work was done before he was thirty. When he was in his fiftieth year he was laid low by spinal paralysis. He suffered tortures, and was confined to his bed for the remainder of his life. In that period, however, mastering pain and infirmity, he wrote much which will assist in maintaining his reputation as one of the greatest of modern poets.

Helena, St.
b. third century A.D. died about 328.

Supposed to have been the daughter of an innkeeper, she became the wife of Constantius Chlorus, who, upon being made emperor, was compelled to divorce Helena and take a wife of more exalted birth. Her only son was Constantine the Great. When he became Emperor of Rome, and a convert to Christianity, she, too, was converted, and, proceeding to Jerusalem, discovered the Holy Sepulchre and the Cross.

Heliodorus
b. Emesa, Syria, fourth century A.D. d. close of fourth century, A.D.

The earliest and best of the Greek romance writers was a member of a family of pagan priests, but himself became a Christian, and was Bishop of Tricca, in Thessaly. He is famous as the author of "Æthiopica," which became the model for all later Greek romance, and has inspired many modern writers. It has been translated into every written language.

Helmholtz, Hermann Ludwig Ferdinand von
b. Potsdam, Germany, Aug. 31, 1821. d. near Berlin, Sept 8, 1894.

One of the world's greatest mathematicians and physicists, he was so poor early in life that he had to begin his career as an army surgeon. His discoveries in physiology soon attracted attention, and brought him a professorship at Königsberg, followed by still higher appointments at Bonn, Heidelberg, and Charlottenburg. His investigations covered an immense field, and to whatever subject he turned it was to bring to light new data. He revolutionised the science of the ear; he opened a new world to the eye specialists; he threw new light upon the nervous system. In chemistry, mathematics, electricity, magnetism, meteorology and theoretical mechanics he was no less successful.

Helmont, Johann Baptist van
b Brussels, 1577. d. near Brussels, Dec 30, 1644.

After several years' devotion to mysticism he turned his attention to chemistry, and helped to reduce it to order out of the chaos to which it had been brought by the alchemists. He was the first to use the balance in chemistry, and gave science the word "gas." His discoveries marked a new departure for a future generation of scientists.

Hemans, Felicia Dorothea
b. Liverpool, Sept. 25, 1793. d. Dublin, May 16, 1835.

For many years this gifted woman was an invalid, and some of her most charming poems were produced during intervals of intense suffering. Her genius was not of the highest order, but lyrics like "The Treasures of the Deep," "The Better Land," "The Homes of England," "Casabianca," "The Palm Tree," "The Graves of a Household," and "The Wreck," may last as long as the language in which they are written. She was the daughter of a Liverpool merchant named Browne, whose reverse of fortune caused his removal to Wales, where she grew up in an atmosphere of romance and mysticism. She married in 1812 an Irish officer. They had five sons; then her husband left her, and they never afterwards met.

Henderson, Alexander
b. Creich, Fifeshire, about 1583. d. Edinburgh, Aug. 19, 1646.

The son of a Fifeshire tenant farmer, he was appointed by Archbishop Gladstanes to the living of Leuchars. The appointment was so unpopular, proceeding from a prelate, that Henderson, for his induction service, had to enter the church by way of a window. He soon identified himself with the popular cause, attained to fame, disputed with Charles I. on public and ecclesiastical affairs, and drafted the National Covenant and the famous Solemn League and Covenant. He was foremost in restoring to the Kirk of Scotland her ancient rights and liberties.

Henry IV. of France
b. Pau, France, Dec. 13, 1553. d. Paris, May 14, 1610.

The author of the Edict of Nantes, which gave perfect religious equality to France, was bred a Huguenot, and as one made himself famous at the head of the Huguenot army. He escaped the massacre of the Huguenots by submitting to Rome, but when at liberty repudiated his conversion, only to recant once more, saying, "Paris is well worth a Mass." By great skill as a general and diplomatist, he overcame all his enemies, and became King of France. He was a wise and humane ruler. To him France owes the inception of her industries; to his gifted Minister Sully the reorganisation of her finances. He planned a great scheme for the union of all the countries of Europe into a federal republic, but was assassinated by a Jesuit fanatic before the world could become acquainted with the details of his plan.

Henry I. of Germany
b. Saxony, 876. d. Saxony, July 2, 936.

Surnamed the Fowler, because of his love of the chase, Henry I. was the promoter of the unity and civilisation of Germany. He expelled the Hungarians, made Austria part of the German Empire, recovered Lorraine, gave the country fortified cities in place of squalid villages, and, great as a statesman and warrior, played a notable part in the upraising of his own country and of Europe generally. Henry II. "St. Henry"—another great soldier and administrator and a zealous Christian monarch, was the great-grandson of the Fowler.

Henry II. of England
b. Le Mans, France, March 5, 1133. d. Chinon, France, July 6, 1189.

Expediency rather than principle dominated the life and actions of this first Plantagenet king. His reign was important to posterity, because of his great legal reforms. He substituted the jury for trial by battle, established assizes and the High Court of Justice. One of the great blots upon his reign was the murder of Becket. From his eldest daughter—Maud—by her marriage to Henry V., Duke of Saxony, the present royal family of Great Britain is descended.

Henry VIII. of England
b. Greenwich, June 28, 1491. d. Westminster, Jan. 28, 1547

Of this King, son of Henry VII. and Elizabeth of York, it has been said that he approached as nearly as possible to the ideal standard of perfect wickedness as the infirmities of human nature would allow. Yet it is impossible to exclude him from the roll of men who have achieved great results. Not because he was more Protestant than his predecessors, but from quite other motives, he overthrew the supremacy of the Pope in England, made the sovereign of this land head and "defender" of the Church, and suppressed

monasticism. He had six wives. The first and fourth he divorced; the second and fifth he beheaded; the third died, after giving birth to the future Edward VI.; the sixth was so fortunate as to survive him.

Hero
b. Alexandria.

The fame of Hero—or Heron—survives, but the exact dates of his birth and death—about 3rd century B.C.—it is impossible now to ascertain. He was a pupil of Ctesibius, the father of hydromechanics, and first applied science to industry. He knew the use of steam, and invented what was practically a primitive steam-turbine. He anticipated by two thousand years the modern hot-air engines, devised an instrument for surveying which was the forerunner of the theodolite, and left valuable writings on pneumatics and on other scientific subjects. His discoveries served no useful purpose in his own age, but they demonstrate wonderfully the genius and skill of the man and of the great Alexandrian school to which he belonged.

Herodotus
b. Halicarnassus, Asia Minor, 484 B.C. d. Thurii, Italy, 424 B.C.

Although a Greek, the great historian of antiquity was born a Persian subject, and helped, it is believed, in the overthrow of the Persian power and in making his native town part of the Athenian union. He travelled throughout Greece, familiarised himself with every part of the coast of Asia Minor, and with Egypt, and lived in Samos and Athens. Considerable as were his travels, he found time for extensive study, and was familiar with the whole range of Greek literature extant in his age. Wherever he travelled, he made himself master of all that there was to be learned of history and institutions, manners and customs. So he equipped himself for his great work, the writing of his History, whose charm to-day is as potent as ever, and whose authenticity is more and more firmly established by modern research. Herodotus was not only the father of history; he was, as De Quincey has called him, the general father of prose composition.

Herschel, Sir William
b. Hanover, Nov. 15, 1738. d. Slough, Bucks, Aug. 25, 1822.

The son of a bandmaster, and himself a professional musician in his youth, he educated himself in mathematics and astronomy, and, too poor to buy a reflecting telescope, made one for himself. Famous among his discoveries was that of the planet Uranus. Herschel was the virtual founder of sidereal science. He was notably assisted in his labours by his brilliant sister Caroline Herschel—who made important astronomical discoveries of her own.

Herschel, Sir John Frederick William
b. Slough, Bucks, March 7, 1792. d. Collingwood, Kent, May 11, 1871.

Herschel's father had but one rival as an explorer of the heavens, and that rival was his greater son. The latter carried on the work which his father had begun, and enormously increased our store of astronomical data. After re-examining his father's work, he published a catalogue of a vast number of stars and nebulæ, and, having exhausted the Northern Hemisphere, completed his work by exploring and cataloguing the stars of the southern one. He was a distinguished chemist, to whom photography owes much; while as a man of letters he made notable contributions to English literature, in the form of translations from the Greek and German.

Hertz, Heinrich Rudolf
b. Hamburg, Feb. 22, 1857. d. Bonn, Germany, Jan. 1, 1894.

One of the most brilliantly successful of modern physicists, Hertz began his career as an engineer, but happily abandoned that vocation for the pursuit of physical science. Following up the work of Faraday and Clerk-Maxwell, he added greatly to the advancement of knowledge of electricity—in its relation to light. His most important discovery is commemorated by the name given to the Hertzian waves.

Hesiod
b. Beotia, Greece, about ninth century B.C. d. Orchomenus.

The father of Greek didactic poetry exercised so great an influence over the minds of his countrymen that he is said, with Homer, to have created the religion of the ancient Greeks. He wrote not to please, but to instruct. Scholars are not agreed as to how many of the works attributed to him were really his, how many received his name which really belonged to the school of poetry which he founded. His career is enshrouded in obscurity, and dates cannot be given with any certainty.

Hill, Matthew Davenport
b. Birmingham, Aug. 6, 1792. d. near Bristol, June 7, 1872

Eldest brother of Sir Rowland Hill, he was as conspicuous for efforts on behalf of the reform of the criminal law as Sir Rowland was in connection with postal reform. He was successively Member of Parliament, Recorder for Birmingham, and Commissioner of Bankrupts, but his greatest efforts lay in the direction mentioned. He was one of the pioneers of the movement for reformatories for juvenile criminals, a work attended by great benefit to the community.

Hill, Sir Rowland
b. Kidderminster, Dec. 3, 1795. d. Hampstead Aug. 27, 1879.

When Hill was a young man it cost 1/4½ to send a letter from London to Edinburgh, and absorbed a fifth of the wages of an Irishman labouring in England who wished to send home a letter. Hill repeatedly witnessed the fear of his mother that a letter should be delivered at her house for which she should be unable to pay. He saw that illicit methods were employed to get letters conveyed, and that the public revenue from the Post Office, instead of increasing with the growth of the national wealth, steadily decreased. His scheme of penny postage was the result of his own personal experiences. It was strongly opposed by the postal authorities, who predicted terrible consequences from its adoption; but by patience, skill, and courage he carried his scheme in the face of almost unprecedented opposition. Appointed finally Secretary of the Post Office, he saw the number of letters dealt with by the Post Office increased from 76 millions to 642 millions a year, and the revenue raised from 2¼ millions sterling to upwards of 3¾ millions. Few men of the nineteenth century accomplished a more notable work for the nation.

Hipparchus
b. Nicæa, Asia Minor, second century B.C. d. Nicæa, about 120 B.C.

The founder of scientific astronomy conducted his experiments with instruments falling short a hundredfold of the precision of those now in use, but his discoveries were of great importance. He catalogued a great number of stars, discovered the eccentricity of the solar orbit, some of the inequalities of the moon's motion, the precession of the equinoxes, and did much in the application of astronomy to geography. Hipparchus was a man of towering intellect, who, armed with the crudest implements, achieved results which, for centuries afterwards, were the basis of all scientific knowledge in the paths he had chosen.

Hippocrates
b. Island of Cos, about 460 B.C. d. Larissa, Greece, about 377 B.C.

The greatest physician of ancient times, a profound scholar and philosopher, Hippocrates was not only the founder of the art of medicine, but prepared the way for men like Aristotle and the great school of Alexandria. Nearly fourscore works bearing his name are in existence. Many of these are forgeries or wrongly attributed to him. A sufficient number of writings incontestably his remains for us to reconstruct the splendid learning of which he was the founder.

Hobbes, Thomas
b. Westport, Wilts, April 5, 1588. d. Hardwick Hall, Dec. 4, 1679.

Scholar and philosopher, associate of Bacon, Galileo, and other intellectual giants, Hobbes produced works of philosophical character, which, while affording a stimulus to thought, brought him into serious difficulty. He was accused of heterodoxy, and even atheism. But, though he submitted to the Commonwealth, he died a Royalist pensioner.

Hofman, August Wilhelm von
b. Giessen, Germany, April 8, 1818. d. Berlin, May 5, 1892.

One of the greatest chemists of the last century, as a young man he was appointed first director of the Royal College of Chemistry in London. He was brilliantly successful. All the future great chemists of his day came under Hofman's influence. It was by one of his pupils that the aniline dyes were discovered. In spite of all his success, his efforts met with no reward in England. Englishmen did not believe in science in commerce. He, therefore, returned to Germany, and gave his native country the secret of the great coal-tar industry, which has been productive of incalculable wealth to her.

Hogarth, William
b. London, Nov. 10, 1697. d. London, Oct. 25, 1764.

Our great satirist upon canvas was apprenticed to a silversmith, but learned drawing in the school of Sir James Thornhill, with whose daughter he eventually eloped. His work as an artist seriously began with illustrations of "Hudibras." Portraits followed, and then the series of cartoons pillorying the vices of his time. His power as a humorist was great; but he was still more a preacher on canvas. Many of Hogarth's drawings are coarse and unlovely, but so were the subjects he attacked.

Hogg, James
b. Ettrick, Selkirkshire, 1770. d. Eltrive Lake, Yarrow, Nov. 21, 1835.

Receiving less than a year's education, this delightful poet became, at seven years of age, a shepherd-boy, and lives in history as the Ettrick Shepherd. It was while working as a shepherd that he was granted access to books which enabled him further to educate himself. Then meeting "a half daft man," who recited some of Burns's poems to him, and said that they were by the sweetest poet that ever was born, Hogg determined that he would make an effort to fill the dead singer's place. His work attracted the attention of Scott and Byron, and both helped him, as did the Countess of Dalkeith. The latter left him a farm at a nominal rent, and he farmed and wrote poetry to the end of his days. Some of his work is exquisitely dainty, and it has been justly said that at his best he might have claimed over all his contemporaries the laurel for direct and immediate inspiration.

Holbein, Hans
b. Augsburg, Bavaria, 1497. d. London, 1543.

He was called Holbein the younger, to distinguish him from his father, who also was a skilful artist, and was his master in painting. Holbein's early manhood was spent partly on the continent, partly in England. Here he painted the portraits of Erasmus, Anne of Cleves, Sir Thomas More, and Henry VIII. He died of the plague upon a date unknown.

Holberg, Ludvig von
b. Bergen, Norway, Dec. 3, 1684. d. Copenhagen, Jan. 28, 1754.

The father of the Danish drama and the greatest figure in Danish literature, he was a man of versatile genius. In addition to his plays, he wrote satires, history, biography, as well as serious reflective works. He also held important academic rank at the Copenhagen University.

Holden, Sir Isaac
b. Burlet, Renfrewshire, May 7, 1807. d. Keighley, Yorks, Aug. 13, 1897.

He was the son of a collier, who, though a poor man, did the best he could for his boy's education. The boy himself was studious, and though a great part of his early days was spent in the factory, he managed so well to equip himself with knowledge that he became a school teacher. While acting in this position he discovered the principle of the lucifer match, though—unknown to him—a Stockton chemist had been before him. His greatest triumph, however, was won in connection with the wool-combing machinery which he invented. This brought great wealth to him and to all associated with him in the business. He was made a baronet four years before his death.

Holinshead Raphael
b. Cophurst, Cheshire. d. Braincote, Warks, 1580.

The author of the famous "Holinshead Chronicle," giving the history of England, Scotland, and Ireland down to his own era, had assistance in his great work, but he was responsible for the enterprise. The work is of great importance to historians, and additionally interesting to us all, from the fact that from this "Chronicle" Shakespeare drew the material for his early English plays.

Homer
Lived about 9th century B.C.

No fewer than seven towns in Greece claim to be the birthplace of Homer, the father of poetry, but no authentic record on the subject exists. Nothing is known of the poet himself; even the story that he was blind and a beggar is a legend. The two great epic poems which we call Homer—the "Iliad" and the "Odyssey"—form one of the most priceless bequests which have come down to us from ancient Greece. It is impossible to determine whether the whole work is by one hand. Both are noble poems, but the differences in general tone and style between the two lead the critics to believe that the "Odyssey" may have been by an unknown later poet, or by one poet welding into a harmonious whole the efforts of a school of poets. It is unlikely that we shall ever approach any nearer to a solution of the mystery. We have the works, and in them Homer, one man or twenty men, lives immortal—the great Greek of Greeks, as Ruskin says—the more notable because of his influence on Virgil, and, through him, on Dante, and all the after ages.

Hood, Samuel, Viscount
b. Butleigh, Somerset, Dec. 12, 1724. d. Bath Jan. 27, 1816.

The son of a clergyman, Samuel Hood entered the Navy as a captain's servant, served as an able seaman, and gradually worked his way up to the rank of admiral. He had a conspicuous place in the sea battles of his time, and, in the words of Nelson, who served under him, was "the best officer, take him altogether, that England has to boast of." He was created a viscount, and made Governor of Greenwich Hospital.

Hood, Thomas
b. London, May 23, 1799. d. London, May 3, 1845.

"He sang the Song of the Shirt" is the epitaph on Hood's tombstone. If he had written nothing else, his days would have been justified. But in grave vein or gay he was always writing, though his health was of the worst, and his fortunes often dismal in the extreme. A business misfortune consumed all his possessions, but he was too honourable to declare himself bankrupt; he mortgaged his brain to work off his liability, and broke down while still at his task. Hood began his career in a merchant's office, and was afterwards apprenticed to an engraver, but was too delicate for the work of either position.

Hooke, Robert
b. Isle of Wight, July 18, 1635. d. London, March 3, 1703.

One of the greatest of experimental philosophers, Hooke anticipated the invention of the steam-engine and of the flying-machine, and made material contribution to mechanics in the direction of ingenious contrivances for clocks and watches. He carried further the scientific manufacture of optical instruments, and afforded Newton valuable assistance in his theory of gravitation. He was delicate and eccentric, but a good man, and very industrious; he earned his place in history as the most notable of philosophical mechanics.

Horace, Quintus Horatius Flaccus
b. Venusia, Italy, Dec. 8, 65 B.C. d. Rome, Nov. 27, 8 B.C.

He was the son of one who, once a slave, had as a freeman attained to means, and was able to give him a sound education. He was a student in Rome at the time of the assassination of Cæsar. Horace took arms under Brutus, and fought as an officer at Philippi. Returning to his home, he found his property confiscated, and himself driven to write verses for a living. Thanks to the friendship of Virgil, he came to enjoy the patronage of Mæcenas, who presented him with a pretty property in the Sabine Hills. Here the greater part of his years were spent, and here were written the famous satires, epistles, odes, and lyrics by which he immortalised himself.

Howard, John
b. London, Sept. 2, 1726. d. Kherson, Russia, Jan. 20, 1790.

A personal experience made Howard a prison reformer. He was on a voyage to Lisbon when captured by a French privateer, and thrown into prison at Brest. The horrors of a fortnight's detention led him, upon his return to England, to inquire into the condition of English prisons. From that time his life and fortune were devoted to the cause of the reform of our gaols. He died while on a tour of inspection in Russia, killed by typhoid fever.

Huber, François
b. Geneva, July 2, 1750. d. Geneva, Dec. 31, 1831

He worked with such assiduity in the pursuit of knowledge that by the age of fifteen he had begun to lose his sight, and eventually became totally blind. But the noble woman to whom he had become engaged married him in spite of his blindness, and was sight to him. Together they made the bee their life-study, and laid the foundation of all our scientific knowledge of the fascinating subject.

Hugo, Victor Marie
b. Besançon, France, Feb. 26, 1802. d. Paris, May 22, 1885.

His father was a general in the army of the Empire, and carried his family with him, as far as possible, to the various places in which he was quartered. Hugo was a phenomenon as a boy – there can never have been another such. Between his thirteenth and sixteenth years he had written every possible kind of verse odes, satires, epistles, poems, tragedies, elegies, idylls, imitations of Ossian, translations from the classics, romances, fables, stories, epigrams, madrigals, logographs, acrostics, charades, enigmas, impromptus, and a comic opera. And yet this boy was destined by his father for a military career! The Academy withheld the prize which he had won for a poem, believing it impossible that the author was only fifteen years of age. His example, Mr. Swinburne has said, will stand for ever as the crowning disproof of the doubtless more plausible opinion that the most amazing precocity of power is a sign of ensuing impotence and premature decay. The boy, in this instance, was father of the man. His literary activity was unbounded. He took his share in the public life of France of his day, and helped to administer the affairs of the country. Napoleon fired his imagination, but the coup d'état of Napoleon III. filled him with indignation, and France and Belgium became successively impossible as places of residence. He retired to Guernsey, where his literary outpourings proceeded unchecked. The fall of the Second Empire recalled him to Paris, where he remained throughout the Commune, but, retiring again to Brussels, was again expelled the kingdom. Paris once more opened her arms to him, and made him a Senator. Almost to the end of his long life he continued to write, and though towards the close of his career he fell below the high standard of his earlier work, his record is almost without parallel for variety of themes and treatment, for nobility of aim and beauty of expression. He has been acclaimed the finest purely literary spirit that France has ever produced.

Humboldt, Friedrich Heinrich Alexander
b. Berlin, Sept. 14, 1769. d. Berlin, May 6, 1859.

As a child he was called "The Little Apothecary," so keen was his devotion to scientific subjects. At twenty he had matured his powers, and resolved upon the career of scientist and explorer. All his studies were directed to that end. He travelled through Europe, spent some years as a mining engineer, resumed his European travels and studies, then made a productive exploring trip to Mexico and South America. For the next twenty years he resided mainly in Paris, engaged in scientific pursuits, then went to Berlin, whence, at the invitation of the Emperor of Russia, he departed on an expedition to Siberia and the Caspian Sea. The monumental results of his investigations were given to the world in thirty volumes of brilliant writings. He found time to discharge numerous important political missions, and was not less esteemed as a diplomatist than as a great master of learning, the Encyclopædia of Science, as Emerson has named him.

Hume, David
b. Edinburgh, April 26, 1711. d. Edinburgh, Aug. 25, 1776.

The famous historian and metaphysician "found himself," after expeditions in various directions in search of a vocation. He first tried the law, then commerce, was at various times companion to men of note, Under-Secretary for the Home Office, and Judge-Advocate. He had attained his forty-first year when he decided to write his "History of England," and completed it nine years later. His political and moral essays, though not invariably attracting great attention at the time of publication, have since had a decided effect upon the opinion of the country.

Hunt, William Henry
b. London, March 28, 1790. d. London, Feb. 10, 1864.

The father of English water-colour drawing was a puny cripple, son of a journeyman tinplate worker. His gift for drawing was inexplicable. It showed itself when he was quite young, and he was soon copying Gainsboroughs at eighteenpence apiece. A good-natured patron of art took him in hand, and gave him an introduction to the Earl of Essex, the interior of whose house formed the subject of Hunt's first picture at the Royal Academy. Ruskin places him among the greatest colourists of this country. He left a fortune of over twenty thousand pounds, all earned by his brush.

Hunt, William Holman
b. London, April 2, 1827.

With Dante Gabriel Rossetti, Millais, and other artists he founded the "Pre-Raphaelite" school of painting, which aims at telling the truth, the whole truth, and nothing but the truth in a painting. The most famous of all his many well-known pictures is "The Light of the World." The original is in the chapel of Keble College, Oxford; a replica has been sent by Mr. Charles Booth on exhibition throughout the British Empire.

Hunter, John
b. Long Calderwood, Lanarkshire, 1728. d. London, Oct. 16, 1793.

Destined to become the founder of modern scientific surgery, Hunter wasted his youth, and never quite made good the opportunities neglected. Spelling and grammar were always too much for him, yet he was the instructor of the great surgeons who were to follow him. He disregarded books, and studied instead men, animals, and plants. His discoveries were of the greatest importance to the science of which he became the chief exponent. All the money which he could spare he devoted to the collection of specimens which, when catalogued years later by Owen, formed a priceless possession to comparative anatomists. Hunter's wife was the author of

"My mother bids me bind my hair," and other popular poems. Among his pupils were Jenner, Astley Cooper, and Abernethy. William Hunter, another great surgeon, was his brother, and gave his more famous junior his first insight into surgery.

Hunyadi, Janos
b. Hunyad, Transylvania, 1387. d. Somlin, Croatia-Slavonia, 1456.
A great Christian general, he was Regent of Hungary during the minority of Ladislaus V. His whole career was one long campaign against the Turks, whom he defeated in many brilliant battles. His most famous achievement was the storming of Belgrade.

Huss, John
b. Prachatitz, Bohemia, July 6, 1369. d. Constance, Baden, July 6, 1415.
His preaching of Wyclif's tenets brought him under the ban of the Roman Catholic church. The Pope by bull condemned Wyclif's teachings, but Huss continued to expound them, was brought to trial, refused to recant, and was burnt at the stake. The Hussite war, which followed, was the outcome of the resistance of his followers offered to the whole forces of the Empire, and sustained for a generation at terrible cost in lives to both sides.

Hutton, James
b. Edinburgh, June 3, 1726. d. Edinburgh, March 26, 1797.
The son of well-to-do parents, he received an excellent education, and was then placed in the office of a lawyer. But his mind from the outset ran wholly on science, and when he should have been studying lawyers' laws, he was probing Nature's. His articles were cancelled, and he was sent to Paris and Leyden to study medicine. This, too, he abandoned, and determined to try scientific farming, which conducted him to mineralogy and geology, in which his interests really lay. His laborious researches led to his discovering the modern explanation of the phenomena of the earth's crust by means of changes still in progress. The "Huttonian Theory" was assailed by his contemporaries, and it was not until the luminous exposition of John Playfair made the ponderous tomes of the founder of geology popular that the significance of Hutton's discoveries was realised. He had no mathematical knowledge, and went astray in adopting the phlogiston theory; but, with every detraction considered, the value of his work remains very high.

Huxley, Thomas Henry
b. Ealing Middlesex, May 4, 1825 d. Eastbourne, June 29, 1895.
The seventh child of a seventh child, Huxley began his education under his father, who had the future Cardinal Newman among his students. For the son of a school teacher, his education was strangely desultory and irregular. "I had two years of a pandemonium of a school between eight and ten—and after that neither help nor sympathy in any intellectual direction till I reached manhood," he recorded. His desire was to be a mechanical engineer, but the study of Hutton's works, of logic, and of German, and the fact that two of his sisters married doctors, fortunately led to his taking other paths. He was apprenticed to a London surgeon, and at his first post-mortem examination contracted an illness which left him with chronic dyspepsia. In his twentieth year he announced an important discovery in relation to the human hair. In the same year he graduated M.B., and won a gold medal for anatomy and physiology. Like Darwin, he was destined to find fame on the sea. He took voyages, in the capacity of assistant-surgeon, in two ships, and in both made important contributions to the science of biology. His fame was now growing, but he had no funds with which to publish the full results of his work. Ordered to rejoin his ship, he had to throw up his only certain income rather than leave unfinished the work of completing the description of his collection of specimens. Fortunately, the position of lecturer on natural history at the Royal School of Mines fell vacant at an opportune moment, and Huxley was appointed. He was now in a position in which he could make his influence felt. Despite lasting ill-health, he addressed himself with heroic energy to the popularising of science. In the great controversy on evolution he played a leading part in support of Darwin. His lectures to his students, to unscientific audiences, and especially to working men became famous. Honours crowded upon him, and no man of science of his era had greater influence. He was one of the first members of the London School Board, and accomplished much for the improvement of popular education. His writings and lectures on scientific and philosophical subjects are by this time for the most part classics. The nineteenth century produced few such splendid brains as Huxley's, few men so strong and courageous and lovable withal.

Huygens, Christian
b. The Hague, Holland, April 14, 1629. d. The Hague, July 8, 1695.
He was the son of a poet and diplomatist, whom James I. knighted, and studied physics, astronomy and mathematics at Leyden University. One of his greatest advantages was his adaptability. He could seize upon and improve a new idea. Thus he invented the pendulum clock, on the suggestion of Galileo; and, developing the same philosopher's theory of the acceleration of motion under the influence of gravity, prepared the way for Newton. Huygens, who first expounded the undulatory theory of light, discovered Saturn's ring and one of his satellites.

Hypatia
b. Alexandria, fourth century A.D. d. Alexandria, fifth century.
The daughter of an Alexandrian astronomer and mathematician named Theon, she learned all that her father could teach her, then went to Athens, where she became so proficient in philosophy that she returned to Alexandria to become noted herself as a teacher. She presided in the public schools, teaching philosophy and mathematics. Her beauty and talent made her very famous, and excited the hatred of a bigoted Christian archbishop, one of whose creatures headed a riot in the course of which she was stripped of her clothing and torn to pieces in the public streets. Kingsley's novel is founded upon her career.

Ibsen, Henrik
b. Skien, Norway, March 20, 1828. d. Christiania, May 23, 1906.
The failure of his father's fortune coloured the early life of the future poet and dramatist. He was apprenticed to an apothecary, but studied literature in his leisure, and before he was twenty-one published his first work. It was a failure, as were several others—dramatic and poetic. He had tried his fortune in journalism and as manager of a theatre before he gained the approving attention of the world with the plays which made him famous. "Love's Comedy," written in his thirty-sixth year, linked his name with the social and satirical drama, and the future held no more difficulties for him, though his works were never received without prolonged and bitter controversy. Ibsenites see in him the stern moralist depicting conditions and life as they are; his critics find him morbid, and a painter of things which ought not to be painted.

Ivan III.
b. Moscow, 1440. d. Moscow, Oct. 27, 1505.
Ivan the Great, as he is commonly called, was born Grand Duke of Moscow. Finding the country divided into many petty states, and tributary to the Mongolian Tartars, he made Russia a whole, and became the first Tsar and founder of the Russian Empire. Ivan the Terrible (b. 1530; d. 1584) was an enlightened but cruel and

barbarous prince, who slew his own son in a fit of passion. He extended the dominion of Russia—notably by the acquisition of Siberia. By him the first printing press was established in Russia, and the mission sent to England by which the first treaty between Russia and this country was signed.

Jacquard, Joseph Marie
b. Lyons, July 7, 1752. d. near Lyons, Aug. 7, 1834.

The inventor of the famous silk-weaving loom which bears his name was the son of poor parents, and while pursuing his experiments had to sacrifice everything he possessed to carry on his work. He was unsuccessful, and became a labourer, then a soldier. It was not until he had entered his fiftieth year that the fame of his invention became public. Even then he still had years to wait before it was perfected. The workpeople of Lyons fiercely resisted its introduction, but he lived to see it in universal use.

Jenner, Edward
b. Berkeley, Glos., May 17, 1749. d. Berkeley, Jan. 26, 1823.

The discoverer of vaccination for smallpox was a son of the rectory. He was twenty-six when he began his investigations, but twenty years had elapsed before the medical faculty accepted his theory. His own hope was that by the universal application of vaccination smallpox would become extinct. He was rewarded by two Parliamentary grants, aggregating £30,000.

Joan of Arc
b. Domremy, France, Jan 6, 1412. d. Rouen, May 30, 1431.

"The Maid of Orleans" was the daughter of peasants. She never learned to read or write, but was characterised by boundless mental and physical activity. At this time the English were masters of the whole of France north of the Loire, and Henry V. of England had been proclaimed King of France. A local saying that France was to be redeemed by a virgin out of the forest of Domremy seems to have impressed the mind of the girl. Although she was devoted to her parents, and received with reverence the spiritual instruction of her mother, she dwelt apart, as it were, and dreamed of the prophecy, until she fancied that she heard supernatural voices declaring that she was the maid appointed to the task. She eventually gained access to the Court of Charles VII., and persuaded him to give her the command of an army. At the head of this force she was brilliantly successful. She raised the siege of Orleans, drove the English from their principal position on the Loire, and had the king crowned at Rheims. Still continuing her campaign against the invaders, she was eventually captured by the English at Compiègne—sold, it is said, by traitors for 10,000 crowns. Arraigned before a spiritual tribunal at Rouen, she was condemned as a heretic, and, according to a version upon which later research casts doubt, burnt at the stake.

Johnson, Samuel
b. Lichfield, September 18, 1709. d. London, Dec 13, 1784.

Johnson owes immortality to his disciple and biographer Boswell. The great literary dictator of his age would not be known to posterity as the man he was but for his faithful henchman, who mirrored his manners, ideas, and diction in a manner which Johnson in his own writings quite failed to do. He was the son of a second-hand bookseller, afflicted, in spite of great physical strength, with a disease for which he was "touched" by Queen Anne. In spite of his prodigious mental activity, he failed to obtain a degree at Oxford during his years of residence. He made two or three attempts as a schoolmaster, but without success, and came to London, accompanied by a pupil, David Garrick. He had already married a widow, whose small fortune a calamity soon absorbed. During many years his life in London was one long struggle with adversity. He was still very poor when he projected his famous dictionary. The publisher agreed to pay him £1,575 for the entire work. To complete it he had to employ six amanuenses, five of whom were Scotsmen, whom he affected so heartily to despise. The dictionary was dedicated to Lord Chesterfield, whose discourtesy and neglect were noted in a letter which has become famous. During the latter portion of his life, Johnson enjoyed a Government pension of £300 a year, and became the centre of that literary circle which Boswell has rendered famous. He had no taste for music or pictures; he had many prejudices, and was dogmatic, and apt to browbeat those who crossed him. But, withal, he was one of the greatest figures of his age—a noble-hearted, lovable man, whose wise and witty sayings are to this day in all men's mouths.

Jones, Inigo
b. London, July 15, 1573. d. London, June 21, 1652.

Like many another genius, this great architect began his career in unpromising circumstances. His father was so poor that he was compelled to pay a debt by instalments so small as ten shillings a month. The boy was apprenticed to a carpenter, but his aptitude for drawing attracted the attention of the third Earl of Pembroke, who sent him to Italy to study. He is said to have designed a palace during this trip for the King of Denmark. His first work of note in England was to design the scenery and machinery for the presentation of plays by Ben Jonson and other dramatists. Following this came his appointment as Surveyor-General, and the beginning of his architectural work. His banqueting-house in Whitehall was intended as part of an immense palace. His Lincoln's Inn Chapel, his residence for the Queen at Greenwich, and many other notable buildings in the capital and the country, caused it justly to be said that "what was truly meant by the art of design was scarcely known in this kingdom until he brought it into use and esteem amongst us here."

Jonson, Benjamin
b. London, 1573. d. London, Aug 16, 1637.

One of the most celebrated poets and dramatists, he was the posthumous son of a clergyman. His mother marrying a bricklayer as her second husband, the boy was taken from school, and put to work at his stepfather's trade. His spirit revolted against it and he fled, to join the Army as a private soldier, and serve bravely in a campaign in Holland. Returning to England, he got himself entered at St. John's College, Cambridge, but was forced back to London, to earn his bread as author and actor. A duel with a brother actor terminating fatally for his antagonist, Jonson was imprisoned, and narrowly escaped execution. At twenty-four he published his famous play, "Every Man in His Humour," and thereafter produced a play annually for several years, in addition to masques and smaller pieces for the Court. His share in a dramatic piece which Court favourites resented nearly cost him his nose and ears, which he was condemned to lose in the pillory. He soon regained the Royal favour, and was appointed Poet Laureate, and, following journeyings on the Continent, was the recipient of an honorary degree from Oxford University. But his health was now impaired, and he died of palsy, and was buried in Westminster Abbey, with the simple epitaph, "O, Rare Ben Jonson." His dramas exhibit pungent humour and profound philosophy. They are unequal, as are his poems; but while Shakespeare is accounted among the gods of English verse, Jonson is in the forefront of the giants. Some of his songs are for all time. In spite of his poverty and hard youth, he was among the most learned men of his age.

Josephus, Flavius
b. Jerusalem, 37 A.D. d. Rome, second century A.D

The great Jewish historian was the son of a priestly house, and so early profited by educational advantages that he was frequently consulted as a youth by the high priests and prominent citizens

upon points of Jewish law. After three years in the wilderness as the pupil of a hermit, he went to Rome. His visit impressed him with the power and resources of that empire, and upon his return he did all he could to dissuade his countrymen from their contemplated rising. His voice was not heeded. He himself was swept into the revolutionary movement, and held important military commands until defeated and taken prisoner by Vespasian. The latter befriended him, and upon becoming emperor gave him a residence in Rome. Here Josephus produced his immortal literary works.

Juvenal, Decimus Junius Juvenalis
b. Aquinium, Italy, first century A.D. d. about 140 A.D.
Little is known of the life of this celebrated Roman satirist. He was the son, either by birth or adoption, of a wealthy freedman, who gave him a liberal education. Half his career was spent at the Bar, where he acquired considerable reputation. Against his will he was sent to Egypt, and resided afterwards for some time at his native place. His immortal satires were directed against the social vices of the early Roman Empire, and underlying them all is a strong dislike of the imperial regime, and regret for the loss of the old Republican system. Dryden's translations of Juvenal are among his finest work.

Kant, Immanuel
b. Königsberg, Germany, April 22, 1724. d. Königsberg, Feb. 12, 1804.
The son of a poor saddler of Scottish stock, he studied at the local university, and never resided away from his native city. He was successively private tutor and university lecturer. He lectured on logic and the various branches of metaphysics, on anthropology, physical geography, and mathematics. His great work, the "Critique of Pure Reason," was twelve years in preparation. It was only during the last twenty years of his life that he was famous, though he had published several treatises, in one of which he predicted the existence of Uranus, which Herschel afterwards discovered. His fame spread throughout Europe as work after work followed his "Critique," and an enormous impulse was given by his labour to critical philosophy, of which he was the founder.

Kay, John
b. near Bury, Lancs., July, 16, 1704 d. France, after 1764.
The inventor of the "fly shuttle" was twenty-nine when granted a patent for this extremely important invention—perhaps the most important improvement ever made in the loom. His patent was unblushingly infringed by the manufacturers of his day, and the costs of litigation almost beggared him. His brain teemed with schemes for further improvements in industrial machinery, but the mob broke in and destroyed everything he possessed. He fled to France, and there died in obscurity and poverty. British industry owes an enormous debt to this poor fugitive, who starved to death in a foreign land.

Keats, John
b. London, Oct. 31, 1795. d. Rome, Feb 23, 1821.
This rare and great genius was the son of an ostler, who had married the daughter of his employer, a livery-stable keeper in Moorfields, London. The poet was born in the house adjoining the stables, and went to school at Enfield, where, after two idle years, he applied himself with extraordinary enthusiasm to the study of literature, of which classical mythology was his favourite. He carried from school some Latin and French, but no knowledge of Greek in the original. Keats inherited a modest competence from his grandfather, a practical old man, who apprenticed him to an Edmonton surgeon. The work did not appeal to the poet; and though he studied for three years at the London hospitals, he withdrew at the earliest possible moment to devote himself to the muse, encouraged by the example, if not advice, of his literary friends, among whom were Shelley and Leigh Hunt. "Endymion," though not free from fault, contains so many beauties that it was hailed with acclamation by all but the terrible "Blackwood" and "Quarterly," which attacked it with characteristic ferocity. He bore the onslaughts bravely, but they left an ineradicable scar. The last volume contains some of his finest work, but his health was broken. His devotion to a sick brother, the fatigues of a walking tour in Scotland, and his passionate love for a woman who did not appreciate him, rendered his condition critical. He went to Rome, and died three months after arrival. He had many friends, one of whom—Severn the artist—accompanied him to Rome, and tenderly nursed him until he died.

Keble, John
b. Fairford, Glos., April 25, 1792. d. Bournemouth, March 29, 1866.
The "sweet singer of Israel" and true saint, as Mr. Gladstone called him, was an Oxford professor and a clergyman. With him originated the Tractarian Movement, culminating in the famous "Tract No. 90." His "Christian Year" is the most famous of his poetical writings. Keble College, Oxford, was erected to commemorate him. It is for students of limited means.

Kelvin, William Thompson, Lord
b. Belfast, June 26, 1824.
His father was Professor of Mathematics in the University of Glasgow, where, at the age of twenty-two, young Thompson was to begin a professorship of natural philosophy which was to last over half a century. Meanwhile, he much distinguished himself at Cambridge University. Not only was he a brilliant student, he was famous as an oarsman. At seventeen he attracted the attention of scientists by a brilliant paper on heat and electricity, which showed quite original method of investigation, and was destined to be of importance to subsequent investigations. Since then his writings on science have been beyond enumeration, and their effect upon the scientific learning of the age above comparison. His inventions are of equal importance. It is by those in the field of telegraphy, and those which form aids to navigation, that he is best known to the public. His share in the Atlantic cable brought him a knighthood; his inventions of the magnetic compass and of his famous sounding-machine, which enables the depth of water to be taken without a ship slackening speed, make his name a household word with sailors. His researches in electrostatics gave us those infinitely fine instruments which embody the perfection of mechanical and geometrical adjustment. He has received all the distinctions possible to a man of science, and his jubilee at Glasgow University drew together a notable gathering of British and European scientists.

Kempis, Thomas à
b. Kempen, Germany, about 1379. d. Zwolle, Holland, July 25, 1471.
His real name was Thomas Hamerken; that by which he is known comes from his birthplace. He was trained in an Augustine convent near his native town, and became eventually its superior. Of all his writings, the "Imitation of Christ," of which he is believed to be the author, is the most famous. No other book, after the Scriptures, has been so often reprinted; none other translated into so many languages. A copy of the work—not the first—in the handwriting of Thomas himself is to be seen in Brussels.

Kepler, Johann
b. Weil, Germany, Dec. 27, 1571 d. Ratisbon, Germany, Nov. 15, 1630.
He was the son of poor gentlefolk, and himself scarcely ever free from domestic worries. His first appointment was that of mathematical lecturer at Grätz, he not having as yet taken any interest in astronomy. Fortunately, he was brought into communication with Tycho Brahé, who directed his studies to the work with which he was to immortalise himself. After labouring for some time with Tycho, Kepler succeeded him as

astronomer to the Emperor Rudolf, and at the death of the older man inherited his vast store of facts, as he had benefited by all that he had learned of him. The publication of his famous astronomical laws formed the basis of Newton's work, and the foundation of modern astronomy.

Kingsley, Charles
b. Dartmoor, June 12, 1819. d. Eversley, Hants, Jan. 23, 1875.
The son of a clergyman, Kingsley, after a successful course at Cambridge, took orders, though at one time he had such religious doubts that he declared his intention of quitting the University for the prairies. He first became curate, then rector of Eversley, interested himself in Christian Socialism, and became one of its most powerful exponents. His earlier novels, written with this purpose in mind, excited extraordinary interest. Under the pen-name of "Parson Lot" he wrote a great number of articles for the Press, further elaborating his doctrines. The latter he put into practice in his daily intercourse with his own flock. He held two professorships, and was made Canon of Westminster and chaplain to Queen Victoria. Miss Mary H. Kingsley was his niece. His second daughter, who in 1876 married the rector of Clovelly, but has since become a Roman Catholic, is the well-known novelist "Lucas Malet."

Kipling, Rudyard
b. Bombay, Dec. 30, 1865.
Inheriting talent from both sides of his family, he was sent home to Westward Ho for his education, then, returning to India, was put to work on a newspaper. The short tales which were later to make him famous were written for the paper with which he was associated, and accepted as additions to routine work not willingly, but as a favour to the author. These he eventually put into book form, issuing them one at a time in slim, paper-backed volumes. They made his name at once in India, and later in England. Since then he has travelled almost as far as his fame. He married an American lady, and nearly died in the land of her birth in 1899. The "Bard of Empire," as he is called, he is also the laureate of the barrack-room. His noblest composition—one which, whatever befall the rest, is sure of immortality—is his grand and splendid "Recessional," written for the Diamond Jubilee.

Kircher Athanasius
b. Geisa, Germany, May 2, 1602. d. Rome, Nov. 28, 1680.
Although he was a great scholar and mathematician, Kircher, who was professor first at Wurzburg of philosophy, mathematics, and Oriental languages, then of mathematics at Rome, is best remembered as the inventor of what is still popularly termed the magic-lantern.

Klopstock, Friedrich Gottlieb
b. Saxony, July 2, 1724. d. Hamburg, March 14, 1803.
The founder of modern poetry in Germany was educated at his native Quedlingburg, at Jena, and at Leipsic. Inspired by Milton, and, to a lesser extent, by Virgil, he published three cantos of his sacred epic, the "Messiah." This at once brought him favour and fortune. The completion of his epic occupied him nearly thirty years. It has been superseded by far nobler works, but its influence in creating a German poetic literature can never be overlooked.

Knox, John
b. Haddington, 1505. d. Edinburgh, Nov. 24, 1572.
The perfect symbol of Reformation in all countries and times, as Ruskin has called him, was first a lawyer in Glasgow, where he was educated at the university, then a priest of the Roman Catholic Church. He next became a tutor, and was brought in touch with a Lutheran reformer, by whom his religious opinions were much influenced. This man, Wishart, was burned at the stake for heresy. His death was avenged by the murder of Cardinal Beaton, whose assassins held the castle in which the crime was committed, and called thither Knox, who was now formally admitted to the ministry. St. Andrews yielded to the French, and Knox was confined to the galleys for eighteen months. Upon his release he travelled and preached in England, was made one of the chaplains to Edward VI., and assisted in the reformation of the second Prayer Book. On the accession of Mary Tudor he fled to the Continent, and came under the influence of Calvin. His "Blasts of the Trumpet Against the Monstrous Regiment of Women" was first directed against Mary of Guise, then Regent of Scotland, against Mary of England and Catherine de Medici, but it complicated his relations with Mary Stuart. When the latter, as widow of the Dauphin, returned to Scotland, the battle between herself and him at once began, and led to the dramatic interviews which have become famous. In the end, thanks mainly to his efforts, Roman Catholicism was abolished in Scotland. The times in which he lived were violent, and the cause which he made his own was endangered by many terrible deeds by his disciples. He himself was rough and rude at times, but the verdict of history upon his life, his acts, and his writings is that no one in England or Scotland who values liberty—national, civil, or religious—can speak of John Knox without reverence and gratitude.

Koch, Robert
b. Klausthal, Germany, Dec. 11, 1843.
It was while practising as a physician that he began those researches in bacteriology which have made him famous. His investigations as to anthrax, Asiatic cholera, rinderpest, and bubonic plague have led to important results. Controversy still rages round the conclusions which he has reached on the subject of tuberculosis.

König, Friedrich
b. Eiselben, Germany, April 17, 1774. d. Jan 17, 1833.
Trained to the trade of a printer, he devoted his leisure to planning a steam press. This, with the assistance of Bensley, a London printer, he was able, in 1810, to patent. In the following year he obtained a patent for a cylinder press, which, in improved form, was adopted three years later for the printing of the "Times."

Lagrange, Joseph Louis de
b. Turin, Jan. 25, 1736. d. Paris, April 10, 1813.
Interested at first in literature rather than mathematics, he eventually devoted himself to his calculus of variations, which had highly important results for the higher branches of physical astronomy. He was for twenty years a professor at Berlin, on the invitation of Frederick the Great; but, turning to Paris, was received with honours and emoluments, to devote the rest of his days to the dissemination of knowledge in the French capital.

Lamarck, Jean Baptiste Pierre Monet de
b. Bazentin, France, Aug. 1, 1744. d. Paris, Dec. 18, 1829.
The founder of invertebrate zoology was for some years in the French Army, from which his retirement was necessitated by an injury. He became bank clerk, studied medicine, and then botany. Securing an appointment at what has since become the Jardin des Plantes, on the creation of the museum, he became responsible for the lowest order of animals, what Linnæus had called merely insects and worms. These he reclassified into ten classes, and, though his work has been superseded by subsequent labourers in the same field, its importance at the time was very great. His researches led him to the theory that altered conditions of life lead to variation of species. He was the forerunner in this matter of Darwin and his school.

Lamb, Charles
b. London, Feb. 10, 1775. d. Edmonton, Middlesex, Dec. 27, 1834.
The best-loved personality in English literature was the son of a man who had graduated from domestic service to the position of clerk to a

wealthy Bencher of the Temple. He was entered at Christ's Hospital—the Blue Coat School—where Coleridge, his lifelong friend and first collaborator, was also a pupil. Lamb became a clerk in the South Sea House, and afterwards in the India House. When he was twenty-one his sister Mary, in a fit of madness, murdered their mother. Thereafter he became her constant guardian, devoting his life to her care. In her lucid intervals she wrote; the comedies in their joint "Tales from Shakespeare" are hers. His early poems were inspired by an attachment which the care of his sister caused him to renounce. His famous essays—the "Essays of Elia"—were begun when he was forty-five, and appeared in "The London Magazine." The name under which he wrote was that of a former clerk in the India House. He enjoyed the friendship of all the literary men of his age, and was recognised as a critic and humorist of the highest order. When, after a generation spent in the service of the India House, he retired on a pension of £450 a year, he went with his sister to Edmonton. His term of rest was not more satisfactory to him than the condition of retirement which he describes in one of his essays. His sister Mary was all her life subject to fits of insanity, and these became more frequent and of longer duration as age increased. His last days were thus saddened by this grief, and also by the loss by death of many of his dearest friends. In life he was the same gentle, merry, tender-hearted, delightful man which his writings suggest, and his position in the affections of posterity can never be assailed.

Landseer, Sir Edwin Henry

b. London, March 7, 1802. d. London, Oct. 1, 1873

The youngest of a talented brotherhood, Landseer was the son of an engraver, who early taught his son the art of drawing from life. When he was yet in his fourteenth year he exhibited a picture at the Royal Academy, while at sixteen he became famous with the picture "Fighting Dogs." From that time forward he was a regular exhibitor at the Academy, of which he became an associate, then a member, and finally declined the presidency. He attained the very highest rank among animal painters. Deer and dogs and horses were his favourite studies. His one fault was that he gave his animals too human an expression. The noble lions at the base of the Nelson monument in Trafalgar Square are of his execution. He received the commission in 1858, and the figures were finally placed in position in 1867.

Lâo-Tsze

b. 604 B.C., Honan, China. d. China, date unknown.

Although five-and-twenty centuries have elapsed since the birth and death of Lâo-Tsze, his birthplace and the temple erected in his honour are still pointed out. He was for some time one of the keepers of the king's archives, but retired to live a life of quiet and contemplation. He bequeathed to his country the religion which, with Buddhism and Confucianism, still holds sway today. It was the simple and quiet life which he preached. He deprecates learning and recourse to arms, and bids his followers requite injury with kindness. Confucius, who was much his junior, went to see him, and was reproved for troubling himself with the affairs of the world. The teaching of this philosopher is contained in his classical "Book of the Way."

Laplace, Pierre Simon Marquis de

b. Calvados, France, March 28, 1749. d. Paris, March 5, 1827.

The son of a farmer, he became a professor of mathematics, and renowned for his mastery of the whole science of mathematics and its application to practical astronomy. For six weeks he was Minister of the Interior under Napoleon. His contributions to science deal with the tides, with lunar motions, and the nebular theory.

Latimer, Hugh

b. Thurcaston, Leicester, about 1485. d. Oxford, Oct. 16, 1555.

The son of a yeoman farmer, he became Bishop of Worcester. He was one of the divines who found in favour of the divorce of Henry VIII. In his forty-fifth year he was, in his own words, "as obstinate a Papist as any in England." From that time, however, he turned strongly to the Protestant faith. Called upon, after the accession of Mary Tudor, to recant, he declined, and died, burnt at the stake, in company with Ridley, saying, "Be of good comfort, Master Ridley, and play the man. We shall this day light such a candle, by God's grace, in England as I trust shall never be put out!"

Lavoisier, Antoine Laurent

b. Paris, Aug. 26, 1743. d. Paris, May 8, 1794

One of the crimes of the French Revolution was the execution of Lavoisier, the father of modern chemistry. A man of exceptional talent, he first exploded the phlogiston theory of combustion. Until this was dispelled, although Black and Cavendish and Priestley were doing brilliant work, substantial progress could not be made. Lavoisier showed that the true theory of combustion was a process of oxidation. This opened up the way to the correct study of life, by rendering the function of respiration and the production of animal heat for the first time intelligible. This was not his only discovery, but it was the most important, as establishing the basis upon which modern chemistry has been built. He accepted a position as tax-farmer in order that he might have funds with which to carry on his experiments; and, popular rage being excited against all concerned in tax-gathering, he was condemned and guillotined when in the prime of life.

Layard, Sir Austen Henry

b. Paris, March 5, 1817. d. London, July 5, 1894.

He had two careers. One was as member of Parliament and Ambassador; the other, and earlier, was the more picturesque, and is that upon which his fame will rest. He discovered and explored the remains of ancient Nineveh, and made important contributions to our knowledge of Babylon and of the inscriptions on Assyrian monuments by which the history of the Old World is revealed.

Leibnitz, Gottfried Wilhelm von

b. Leipsic, July 6, 1646. d. Hanover, Nov. 14, 1716.

Equally celebrated in philosophy and mathematics, Leibnitz is regarded as having possessed one of the finest minds of his own or any other time. He inherited a bent for philosophy from his father, and was free to pursue his education under the wisest thinkers. With the Elector of Mainz he was engaged in literary and political work. A similar appointment at the Court of Hanover led to his undertaking a history of the House of Brunswick, and the character of his labours entitles him to be regarded as one of the first of the critical school of historical research. He was the inventor of the calculus. It is claimed for Newton that he arrived at the same discovery by independent research. The point was the source of long and acrimonious debate between followers of the two men, but there seems little doubt now that the German was really the pioneer. He visited England, and met the members of the Royal Society, and endeavoured to institute similar bodies in all the capitals of Europe. His discoveries as to the laws of energy, his work in material directions for the better health and comfort of his fellows, his part in the theological discussions of the age, all show the universality of his genius.

Leo I., the Great

b. Rome, about 390. d. Rome, 461.

One of the greatest of the Roman fathers, he was of a good Tuscan family, and during his early manhood was employed in distant missions, which brought him in contact with St. Augustine. He

was called to the Papal chair when absent on one of these errands. He entered with spirit into the duties of his high office, and established a precedent by preaching from his own pulpit. When Attila overran Italy, and had Rome at his mercy, it was Leo who interceded for the capital. He was less successful when the Vandal Genseric invaded Italy. Rome was sacked, but the Pope managed to induce the conqueror to forgo some measure of the conqueror's licence. The remainder of his days Leo devoted to repairing the ruin which the barbarians had wrought. The Roman Empire had fallen, to rise no more; but, thanks to his efforts, Rome now became the spiritual centre of the West.

Leonardo da Vinci
b. Vinci, Italy, 1452. d. Cloux, France, May 2, 1519.

One of the most richly-endowed of Nature's sons, he excelled in art, in sculpture, in all forms of engineering, in music, and in writing. His father was a Florentine notary, who gave him the advantage of study under the greatest masters of the age. But it was as engineer to the Sultan of Cairo that the artist first attracted attention. He resumed the old life years later, when he was appointed to drain the plains of Lombardy, as well as direct the Court pageants. Few of his paintings remain. One, however, "The Virgin of the Rocks," is in the National Gallery, London. His famous "Last Supper," still, after four hundred years and in spite of many restorations necessitated by damp, one of the greatest art treasures in the world, was painted on the refectory wall of the Santa Marie delle Grazie Convent. His most notable sculptural work was the equestrian figure of Duke Francesco of Milan, a colossal and noble statue, which the French destroyed in 1800. Apart from his great subject pictures, he painted many lovely easel pictures; but the student now must rely mainly upon his drawings, of which many authentic collections exist in England and on the Continent. His celebrated treatise on painting was published in 1651.

Le Sage, Alain René
b. Sarzeau, Brittany, May 8, 1668. d. Boulogne, Nov. 17, 1747.

Having failed at the Paris Bar, he turned to literature, and poured out plays, stories, and translations. Most of them were failures. His famous play "Turcaret" was at first rejected. His fame rests upon that and upon his greater work, the immortal novel "Gil Blas." The originality of the work is challenged; his enemies called it a mere conveyance from Spanish sources. But, though the scene and characters are Spanish, the treatment is essentially French, and the result and glory his. He was the first to see the possibilities of the picturesque novel, and later writers of romance owe him an immense debt.

Leslie, Sir John
b. Largo, Fifeshire, April 16, 1766. d. Coates, Fifeshire, Nov. 3, 1832.

The son of a carpenter, he was enabled, by the kindness of the eighth Earl of Kinnoull to study at the University of St. Andrews. Engaged by his friends the Wedgwoods to superintend their studies, he had time for experiment and research, which resulted in the production of a differential thermometer, a hygrometer, and a photometer. Afterwards he travelled much, and conducted inquiries into the nature and properties of heat, with the result that he was the first to announce important discoveries in relation to the radiation of heat. He also first announced the process of artificially freezing water—a discovery of considerable importance. He became mathematical professor at Edinburgh University, and made many notable contributions to the scientific literature of his age.

Lesseps, Ferdinand Viscomte de
b. Versailles, Nov 19, 1805. d. Paris, Dec 7, 1894.

Educated for a diplomatic career, he went, in the course of his profession, as French Consul-General to Alexandria. When he returned, years later, on a visit to Egypt, he unfolded to Said Pasha, the then Viceroy of Egypt, his scheme for the Suez Canal. The project met with fierce opposition, nowhere more severe than in England. In spite of all difficulties, however, the work was carried to a successful conclusion, and to-day England is paramount shareholder in the canal. Honours were heaped upon the engineer, but with his scheme for the Panama Canal came ruin. Enormous sums were involved in the work, and in 1892 he, with five directors, was condemned to imprisonment for breach of trust. He was too ill to undergo sentence, and died at his own house in the following year. De Lesseps was a cousin of the Empress Eugénie.

Leverrier, Urbain Jean Joseph
b. St. Lô, Normandy, March 11, 1811. d. Paris, Sept 23, 1877.

He at first intended to devote himself to chemistry, but a post as teacher of celestial physics was offered to him, and he became one of the greatest astronomers of his age. Certain planetary irregularities led him to investigate the cause. He predicted that the origin of the disturbance would be found in the existence of a then unknown planet. Unsuspected by Leverrier, Adams, the English astronomer, had at about the same time committed himself to a like prediction. Within a few days of the Frenchman's announcement, Galle, of Berlin, actually discovered the planet--Neptune. The two prophets shared the honours of the prediction. Leverrier had a share in shaping the political destinies of France, but it is in astronomy that his fame is established.

Liebig, Justus Baron von
b. Darmstadt, Germany, May 12, 1803. d. Munich, April 18, 1873.

One of the greatest chemists of all time, Liebig claims the gratitude of posterity not only for the immense amount of data which he himself added to the stores of knowledge, but for the enormous impulse to the study and development of chemistry which he gave through the hosts of brilliant students who during two generations sat at his feet. His father was a drysalter, and the boy was fired with a desire to become a chemist from reading old-time experiments. The result of his labours was the foundation of agricultural chemistry, in itself sufficient to make him for all time famous. In addition, he shared in the discovery of chloroform and chloral, and in the extension of the functions of organic and animal chemistry. He invented an extract of beef which has made his name known throughout the world. As professor of chemistry at Giessen and Munich, his lectures attracted students from all parts of the civilised world; and so great was he as a teacher that he trained his sons in science almost to equal him in his own day. His successors, of course, go far beyond the frontiers to which he had advanced, but as a pioneer his work was of incalculable value and merit.

Lincoln, Abraham
b. Kentucky, U.S.A., Feb 12, 1809. d. Washington, April 15, 1865.

The sixteenth President of the United States of America was the son of a backwoodsman, and was born in the wilds of Hardin County, Kentucky. He received an education which could barely be said to comprise the three R's; but he did learn to read. During youth and early manhood he was successively farm labourer, boat-hand, splitter of rails for his father's log hut, salesman in a tiny store of his own which made him bankrupt. Then he began to study grammar and law, and qualified himself for the acceptance of a minor State office, and to contest a seat in the Legislature. He practised law at Springfield, fought in a war against Indians, then resumed his attempts to enter the Legislature. Successful at last, he attracted widespread attention as an unbending opponent of slavery. Finally, in 1858, he was elected, as a Republican, President of the United States. His election precipitated a crisis in the affairs of the nation. The slave-owning states, seeing that an end of temporising had come, seceded from the

Union, so that they might be free to retain their slaves. The North determined that the South should neither retain slaves nor secede from the Union. The result was the most terrible civil war in history. Lincoln, as President, issued a proclamation liberating all slaves. He behaved with courage, fixity of purpose, and diplomacy throughout the war, and had been re-elected for a second Presidential term before the conflict ended. It was while he was occupied with plans for the reconstruction of the devasted South that he was assassinated at a Washington theatre by an actor named Wilkes Booth. He was one of the greatest men America has produced. A sincere Christian, though not attached to any one church, he was truthful, honest, abstemious, a pattern of morality and probity. He was the saviour of his country and the emancipator of a race.

Linnæus, Carl

b. Råshult, Sweden, May 23, 1707 d. Upsala, Sweden, Jan. 10, 1778

The founder of modern botany was the son of a poor clergyman, from whom he inherited his love of Nature. Declining to devote himself to a clerical life, the boy was apprenticed to a shoemaker, but managed to work his way to the Universities of Lund and Upsala, living on £8 a year, and making his own boots from the bark of trees. Luckily, he attracted the notice of a man whose interests were similar to his own, and for the future his path was smooth. When twenty-four, he was sent on an expedition to Lapland, whence he returned with a mass of new material on natural history. Befriended in Holland by Boerhaave, he was given charge of the gardens and collection of a wealthy Haarlem merchant. His career closed with an appointment to a professorship of physic and botany. He devised the system of classification of the animal and vegetable world called, after himself, the Linnæan system, and his grouping has been of inestimable value to succeeding generations of botanists.

Lister, Joseph, Lord

b. Upton, Essex, April 5, 1827.

The son of a scientist, he has held during his career professorships at Edinburgh, Glasgow, and King's College Hospital, London. He was house-surgeon to the great Syme, whose daughter he married. His original work has included observations on the coagulation of the blood, on inflammation, on the fibre of the involuntary muscles. But his greatest triumph—the greatest triumph in surgery of the age - has been the introduction of the antiseptic treatment. The effect of this is so great that it seems impossible to realise that the reform has come about within living memory. The use of anæsthetics took surgery at a bound far in advance of the methods of the past. The surgeon had no longer to depend simply upon nerve and speed for the successful performance of an operation. His patient feeling no pain during the operation, he was able to do his work carefully at his leisure, and to observe all the signs necessary to the proper treatment of the case. But to counterbalance this boon there were the deadliest after-effects. The wounds became corrupt, and the healthiest patients died of blood-poisoning. People were afraid to enter hospitals, so terrible was the mortality rate after operations. New wards, new hospitals, were built, in the belief that the fault lay with the old buildings, but the deaths in the new buildings were as numerous as in the old. Lord Lister, seizing upon the discoveries of Pasteur as to the prevention of putrefaction by atmospheric organisms, saw that he must render the wound insusceptible to the influence of these deadly foes. His purpose was effected by the use of carbolic acid. First methods were necessarily crude, but these led step by step to the ultimate goal. The highest honours have been bestowed upon this great benefactor of the human race, and his fame is world-wide. He is the first man ever called to the House of Lords in recognition of his supreme eminence as a medical man.

Liszt, Franz

b. Raiding, Hungary, Oct. 22, 1811. d. Baireuth, Germany, July 31, 1886

The Paganini of the piano determined that he would attain to that degree of perfection after hearing the great violinist play. He was already master of the instrument, having played, when only nine years of age, at a great concert at which Beethoven was present. In recognition of his talent, six Hungarian nobles had defrayed the cost of his education. His career as a virtuoso began in his twenty-eighth year, when he won triumph upon triumph in the great cities of Europe. His earlier performances had won appreciation and wider knowledge for the work of Beethoven. He was now able to introduce the music of Wagner, Berlioz, and Chopin. Settling down for a time as director of the Court Theatre at Weimar, he produced Berlioz's "Benvenuto Cellini" and two of the operas of Wagner, to whom a daughter of his was married. In 1865 Liszt entered the Church, to be known thenceforward as the "Abbé Liszt." His compositions, which previously had been brilliant works for the pianoforte, now became mainly suited to the use of churches. Before his death he was ennobled and granted a handsome pension by his native country.

Livingstone, David

b. Blantyre, Lanarkshire, March 19, 1813. d. Ilala, Africa, May 1, 1873

The son of quite a poor man, he had to begin work as a piecer in a cotton factory when ten years of age. With his first wages he bought a Latin grammar, and by its aid mastered Virgil and Horace. His evenings were devoted to study, although he had to be in his place at the factory by six o'clock in the morning. While at work he used to fix his book on the spinning-jenny, so that he might glance at it in passing. At nineteen he was earning enough money to admit of his attending classes for the study of medicine, Greek, and divinity. He had already made up his mind to be a missionary. It was to China that his heart turned, and he would have gone there had not the opium war prevented it. He went to Africa instead, and there found his vocation as missionary and explorer. His first work was among the Bechuana, whom he befriended as doctor and missionary. During these years he married a daughter of his friend and leader, Dr. Moffatt. The failure, through Boer dislike, of his proposal to plant native missionaries in the Transvaal, set him upon his travels. Without attempting to tell the whole story of his stirring career, of his voyages to and from England, his receptions and honours, it is possible briefly to summarise his achievements. He discovered Lake Ngami in 1849; explored the Zambesi and Kuanza basins to Loanda, 1851-4; recrossed the continent from Loanda to Quilimane, discovering the vast Victoria Falls, in 1855; led a Government expedition up the Zambesi and Shire rivers, and discovered Lakes Shirwa and Nyassa, 1858-9; explored the Rovuma Valley in 1866, the Chambezi in 1867, and Lakes Tanganyika, Moero, and Bangweolo, 1867-9; was at Ujiji in 1869; navigated Tanganyika, and was relieved when in precarious plight by Stanley, at Ujiji in 1871; parted from Stanley at Unyanyembe in 1872, and returned to Lake Bangweolo. During these years he had had many trials, mental as well as physical. He had been grieved by the prevalence and extension of the slave trade carried on by the Portuguese, and had battled strenuously against it. He had suffered severely from privation and fever and dysentery. He succumbed at last at Ilala. His faithful native servants found him dead in the morning. He had passed away as he knelt at prayer. They reverently embalmed his body and carried it to the coast, to be brought home and laid in Westminster Abbey. Livingstone was a great Christian hero, a bold and skilful explorer, whose services to humanity and to geography were of the highest order.

Livy, Titus Livius
b. Patavium, Italy, 59 B.C. d. Patavium, 17 A.D.
Of patrician birth, he became a favourite at the Court of Augustus, but never hid the fact that his sympathies were with a republican form of Government. His fearlessness and impartiality are reflected in his monumental work, his history of Rome. To this great undertaking he devoted forty years of his life. It was in 142 books, of which thirty-five are extant, and traced the story of Rome from her beginnings down to the first decade after the birth of Christ. This, the chief of his life's work, placed him in the forefront of prose writers of the Augustan age.

Locke, John
b. Wrington, Somerset, Aug. 29, 1632. d. Oates, Essex, Oct. 28, 1704.
His father, a country lawyer, had served under the Parliament in the wars of the Commonwealth. Locke's sympathies inclined the same way, which fact, coupled with his ill-health, made it desirable for him to reside abroad--mainly in Holland--until after the Revolution of 1688. His immortal essay on the "Human Understanding" was published in 1690, and remains to this day one of the most notable contributions to the philosophy of the human mind. His writings on toleration and government have had a great influence in diffusing free and generous sentiments through European and American systems of government. He at one time intended to be a doctor, and did practise a little. His skilful diagnosis of the complaint from which Lord Shaftesbury, his friend and patron, suffered was the beginning of their friendship. Newton also was among his friends, and they had long corresponded when mighty things were being accomplished by them in the world of abstract science.

Lodge, Sir Oliver Joseph
b. near Stoke, Staffs, June 12, 1851.
While acting first as Professor of Physics at Liverpool University, and as Principal of Birmingham University, he has found time to undertake original experiments of the highest importance. He is one of the pioneers of wireless telegraphy, and has in hand an invention for dispelling fog. Actively interested in religious and social questions, he has made striking contributions to the literature of both subjects. Psychical research also engages his sympathies and keen attention.

Longfellow, Henry Wadsworth
b. Portland, Maine Feb. 27, 1807. d. Cambridge, Mass., March 24, 1882
At nineteen he was sent by the trustees of his college to Europe to study languages, and passed two profitable years on the Continent. This qualified him for the chair of Modern Languages and Literature at Harvard, which he occupied for seventeen years. He wrote his first poem as a boy, and to the last the muse seldom deserted him. He is the one American poet whose poems are universally known. His poems are songs of gladness and sweetness and purity. He is the poet of life, as Poe is the poet of death. Longfellow was twice married, and several times visited Europe.

Longman, Thomas
b. Bristol, 1699. d. London, June 18, 1755.
The son of a soap-boiler, he was apprenticed to a London bookseller, and founded the great publishing house of Longman & Co., by whom, during the last century and a half, some of the finest works in the English language have been issued to the world. He began business for himself by buying out the first publisher of "Robinson Crusoe," in premises whose site is still occupied by the firm.

Low, Sampson
b. London, Nov. 1797. d. London. April 16, 1886.
The son of a printer and bookseller, he established the famous publishing house of Sampson Low & Co. His own house contributed works of great value to literary students—works of reference, indexes, and so forth. Many excellent philanthropies were assisted by his judicious and generous efforts.

Lowell, James Russell
b. Cambridge, Mass., Feb. 22, 1819. d. Cambridge, Mass., Aug. 12, 1891.
Essayist, poet, scholar, and diplomatist, he filled the chair at Harvard which Longfellow had formerly occupied. Although he was a successful Ambassador to Spain and England, he never better served the cause of his country and humanity than in his poems. "The Biglow Papers," were called forth by the efforts of the North to free the slaves. Of the latter he was an unswerving and warm-hearted friend.

Loyola, Ignatius de
b. Loyola, Spain, 1491 d. Rome, July 31, 1556.
Iñigo Lopez de Recalde was the real name of the founder of the Jesuits. In his youth he was the very prototype of Don Quixote; but a serious injury, which left him crippled for life, caused him to turn his attention to loftier ideals than those of chivalry. The Church of Rome was at that time reduced to the depths of degradation by corruption and the luxury of its dignitaries. After making a pilgrimage to the Holy Land, he established the Society of Jesus, whose members were to be missionaries, to go to the uttermost parts of the earth at the bidding of the Pope, to convert the heathen to Christianity. The future of this society was destined to be very different from that which he had planned; but the name of Loyola stands out in the Catholic Church as does that of Luther in the Protestant.

Lucian
b. Samosata, Syria, about 120 A.D. d. Egypt, about 200
His father was a poor stonemason, and intended him to follow the same trade with himself; but Lucian managed to get an education, and to maintain himself as an orator and advocate. Thereafter he settled at Athens, where his literary works were composed. Of these many remain. They are brilliant satires, parodies, and mock narratives of travel, upon which tales such as "Gulliver's Travels" are modelled. He is alleged to have been torn to pieces by dogs, but that is probably an invention of the early Christians, the more likely version being that he died in peace in Egypt, whither he had gone to enjoy a lucrative office.

Lucretius, Titus Carus
b. Rome, about 99 B.C. d. Rome, about 55 B.C.
Little is known of the personal history of this celebrated Roman poet and philosopher. He was the intellectual link between Ennius and Virgil. He lived the life of a recluse. One version as to his death has it that he committed suicide in a fit of insanity; the other, with which Tennyson's poem has familiarised us, that he was poisoned by a love-philtre administered by his wife Lucilia.

Luther, Martin
b. Eisleben, Saxony, Nov 10, 1483. d. Eisleben, Feb. 18, 1546.
His father was a working man, who gave him a university education, and greatly regretted his entering a monastery. It was here, however, that the reformer was enabled closely to apply himself to the study of the Scriptures, and to develop his powers as an orator. His first sign of disagreement with the Church of Rome was brought about by the shameless sale of indulgences. Luther nailed on to the church door of Wittenberg a denunciation of this traffic, and of the Pope's title to forgive sins. The Pope summoned him to Rome. Luther refused to obey the summons. His works were ordered to be burnt, and the Pope excommunicated him. Luther retaliated by burning the Papal Bull containing the sentence upon him. The reformer published his famous "Address to the Christian Nobles of Germany," following it up with his treatise on the "Babylonish Captivity of the Church." Matters had now assumed so serious an aspect that Charles V. summoned him to attend the Diet of Worms, where, in

spite of a powerful defence of his doctrines, he was proscribed. After this he was for some time in hiding, and turned the period to account by translating the New Testament into German. The Old Testament was afterwards similarly treated, and the hymns were written and published from time to time. His writings had immense influence. They created the modern German language. The effect of his stand against the Pope was far-reaching. Europe started like a giant from sleep at the blasts of his trumpet. Dauntless, inspired, invincible, he was rough and violent in his battles, but it was against unprecedented odds that he was matched. When he thought he saw the devil, he threw his ink-horn at the apparition. That was characteristic of his methods. He stands out a great, magnificent figure, initiator of an impulse which became a mighty struggle still in progress. After he had finally broken from Rome, he renounced his monastic habit and married.

Lyell, Sir Charles
b. Kinnordy, Forfarshire, Nov. 14, 1797. d. London, Feb 22, 1875.

A good classical scholar, a man of many friends, Lyell must have distinguished himself in whatever pursuit he had followed. Geology was his absorbing passion. His "Principles of Geology" ranks next to the "Origin of Species" as among the books which influenced the scientific thought of the century. Darwin rated his work very highly, saying that no other geologist had ever done as much for science as Lyell. He was very near-sighted, a fact which may have accounted for his being not the keenest of field observers.

Lytton, Edward George Earle Bulwer, Lord
b. London, May 25, 1803, d. Torquay, Jan 18, 1873

His father was a general; his mother, Elizabeth Barbara Lytton, heiress of Knebworth. After a university education he married, against his mother's wishes, a beautiful woman, with whom his union proved very unhappy. Husband and wife parted after nine years. In that time, to maintain his house, he had produced novels, plays, essays, reviews. He continued an indefatigable workman to the end of his days. After he had inherited Knebworth, he entered Parliament, and became a successful Colonial Secretary.

Macadam, John Loudon
b. Ayr, Sept. 21, 1756. d. London, Nov. 26, 1836.

The man who, in modern England, first gave us good roads—the "macadam" roads, called after himself—was taken by his parents to America, but came back to England, and undertook victualling appointments for the Navy. His road-making experiments were begun at Bristol, and afterwards extended to London. His labour brought him to poverty, and he was voted £10,000 by Government.

Macaulay, Thomas Babington
b. Rothley Temple, Leicestershire, Oct. 25, 1800. d. London, Dec. 28, 1859.

With the story of his childhood every schoolboy is familiar. He was another Victor Hugo in his amazing precocity. His career at Cambridge did not realise all the expectations which his friends had formed; but, nevertheless, he got his coveted fellowship, and faced the world one of the completest scholars ever known. Not only was his scholarship wide and deep; his memory was abnormal. What he read he never forgot—prose or poetry. This was of immense help to him in his writings, essays, criticisms, and history. His early career was threatened by the failing fortunes of his father, and it stands to his credit that three years after he had entered public life he contemplated retirement rather than go with a weak-kneed Government which paltered with principles dear to him. Minor offices paved the way to his going to India as a member of the Supreme Indian Council, at Calcutta. The result of his work became, eventually the admirable Indian penal code. What he gained in knowledge of Indian life is reflected in his superb essays on Clive and Warren Hastings. Upon his return to England, he twice represented Edinburgh in Parliament, but literature absorbed his interest. His history was the ambition of his life. He had brought it down to the reign of William III. when death stayed his hand. That, like his essays, is a masterpiece of writing—as a picture of historical pageants, as portraiture of men; but it does not bear the analysis of the impartial student of history. He was a partisan, and let his partisanship influence his judgment on affairs of which he had undertaken to narrate the true story. Still, there is in the history that which not even Gibbon could have equalled, and, for all his honest prejudices appearing again and again, it lives as one of the glories of English literature. Macaulay was famous as a conversationalist. He was a hard-hitting enemy in public, but a true, loyal, and generous friend, and one of the best-loved men of his age.

Machiavelli, Nicoli di Bernardo dei
b. Florence, May 3, 1469 d. Florence, June, 22, 1527.

Descended from a noble but impoverished family, he lived in an age when troubles were heavy upon Florence. He saw the Medici expelled, the Republic instituted and dissolved, and the Medici reinstated. In the meantime he had fulfilled many diplomatic missions, and taken a prominent part in public life. The restoration of the Medici led to his being put to the torture as a conspirator against the ruling family. Thereafter he retired, to devote himself, for the greater part of his remaining years, to literature. He presented a notable report to Leo X. on the reforms for Florence, and afterwards acted as ambassador. His name has been made the synonym for deceit and villainy. His aims and purpose were misunderstood by early commentators. Modern critics hold that Machiavelli was a man whose public conduct was upright and honourable, whose views of morality, where they differed from those of the persons around him, differed only for the better. His fault was that, having adopted some of the maxims then generally received, he arranged them more luminously, and expressed them more forcibly, than any other writer.

Macmillan, Daniel
b. Arran, Sept. 13, 1813. d. Cambridge, June 27, 1857

The son of a small farmer, he came to London as a raw lad, worked for some years in the employ of a Cambridge bookseller, then with a man of the same trade in Fleet Street, and finally, with his brother Alexander, founded what has since developed into the famous publishing house of Macmillan & Co.

Maeterlinck, Maurice
b. Ghent, 1864.

Educated in a Jesuit college, he forsook the law for literature. Falling early under the influence of Villiers de l'Ile Adam, in Paris, he gave to the world a succession of powerful dramas which have made him world famous. Of a different type, and happier, is his "Life of the Bee," which, whatever be the ultimate verdict upon his other works, seems to assure him lasting fame.

Magellan, Ferdinand
b. Sabaroso, Portugal, about 1480. d. Philippine Isles, April 27, 1521.

Brought up at the Portuguese Court, he served for some years in the East Indies, after which, feeling himself slighted, he took service with Spain. He sailed upon an expedition from which he was fated not to return. On the way, he proved that America is not a great continent stretching away to the South Pole. He made his way, by the straits which bear his name, to the great ocean which he named the Pacific. Reaching the Philippine Islands, he was slain by natives. One of his ships continued on her way, and sailed round the globe, for the first time in the history of the world. The feat was not equalled until Drake was successful more than fifty years later.

Mahomet
b. Mecca, Arabia, 570 A.D. d. Medina, Arabia, June 8, 632 A.D.

There are half a dozen renderings of the name Mahomet, which means "praised," or "the praised one." His father was poor, but of exalted lineage, one of the dominant tribe of Mecca. The Prophet was early left an orphan, and was educated by relatives. He became a soldier, and after that a shepherd. His travels brought him in contact with Jews and Christians, in scenes where idolatry was generally practised. Married at twenty-five, he was fortunate to have for helpmeet a rich woman, who loved and revered him. He would often flee the society of men, and seek the solitude of a cave beyond their reach. Here he pondered over what he had learned of Jew and Christian and from Arabian fable. He was seized with fits of alternating exaltation and despair. At last he became convinced that he had been sent into the world as the prophet of the one true God. His wife believed in his mission, and a few other converts were made. It took three years to get a congregation of forty believers. When once news of the new faith was noised abroad, persecution sharp and protracted followed. He had to flee from Mecca to Medina. Hitherto he had been simply a spiritual teacher; but now he gathered warriors about him, and conflicts many and bloody resulted before he subjugated his enemies. Slowly the faith which he preached made its way. Towards the close of his life progress was rapid, and he was able to add a temporal character to his rule. Mecca remained a holy city, but idolatry was swept away. His teachings were embodied in the Koran, the holy book of the Mohammedans. He pretended and, possibly, partly believed—that he received the laws which he interpreted direct from the angel Gabriel. Those laws, however, are largely drawn from the Old Testament and rabbinical sources. His followers to-day number one-sixth of the human race.

Manzoni, Alessandro
b. Milan, March 7, 1785. d. Milan, May 22, 1873

The founder of the modern Italian school of romance was the grandson of a great scholar, and was introduced early in life into the best literary circles in Italy. Beginning with sacred lyrics and a defence of the religious basis of morality, he startled the world first with a romantic comedy, followed by "Il Conte di Carmagnola," a novel which at once made him famous throughout Europe. The death of Napoleon called from his pen one of the noblest odes in modern literature. His life was singularly beautiful, though his griefs, through the loss by death of all those dear to him, were many and heavy.

Marconi, Guglielmo
b. Bologna, Italy, April 25, 1874

He studied first at Bologna, and then at Leghorn University, but began his experiments in wireless telegraphy at home. When only twenty-two years of age, he sent messages by his system across the Bristol Channel. His invention was adopted in 1900 by the Admiralty for a term of years; while the battleships of the Italian Navy, as well as those of this country, and many of the vessels of the ocean lines and mercantile marine, have since been fitted with his apparatus. Lloyds' stations at home and abroad and many of our lighthouses employ his system.

Marcus Aurelius
b. Rome, April 26, 121 A.D. d. Vienna, March 17, 180.

One of the noblest of the Roman emperors, his name originally was Marcus Annius Verus. He was adopted by Antonius Pius, Hadrian's successor, and eventually succeeded to the throne. He was more philosopher than warrior, and generously shared his dominions with his adoptive brother. His reign was marred by wars and pestilence. Though hating war, he became at the call of duty a great captain. Wherever he led his armies, a host of philosophers followed in his train. His immortal "Meditations," one of the most remarkable books in the Greek language, was really his diary. Its pages were never intended for any eye but his own. They represent the thoughts and feelings of a man of singularly pure heart and noble mind. He aimed at the highest standard of life of which he could conceive, and lived up to that standard.

Mariette, Auguste Edouard
b. Boulogne, Feb. 11, 1821 d. Cairo, Jan. 19, 1881.

His father was town clerk of Boulogne; but Mariette, after a liberal education, took a post at the grammar school, Stratford-on-Avon, after which he worked as a pattern-maker for a ribbon manufacturer at Coventry. Unable to settle, he returned home, and by chance was placed in possession of a mass of papers on matters relating to ancient Egypt. This changed the whole course of his life. He mastered the subject, and devoted the rest of his days to it. He excavated innumerable monuments and inscriptions in Egypt, working unweariedly in spite of ill-health. The world owes him gratitude for a vast store of knowledge of the ancient world. He lies buried in a sarcophagus in an Egyptian garden overlooking the great museum which is his noblest monument.

Marlborough, John Churchill, Duke of
b. Ashe, Devon, June 24, 1650. d. near Windsor, June 16, 1722.

The son of an impoverished Royalist, he was first page to the future James II., and a great favourite of Court ladies, one of whom—the Duchess of Cleveland—presented him with £5,000. Entering the Army, he saw a good deal of fighting; but promotion did not come his way until he married Sarah Jennings, who was to become in all but name Queen of England. He was now elevated to the peerage, but went over to William of Orange when the tide turned. His military exploits in Ireland and against the French did not establish his loyalty to the new dynasty, for he was imprisoned for complicity in Jacobite intrigues. Quickly restored to favour, he was promoted to the command of all the British forces, and in that capacity successfully fought one half of Europe, while at the same time keeping the other half in fighting order. He was a great general brave and modest, fearless and determined, yet a merciful conqueror; but he was one of the most avaricious men that ever lived, and not among the most truthful. He has, however, to be judged by the standard of his time. Rewards were heaped upon him by his country. His wife, the famous Duchess of Marlborough, who long survived him, became for many years dictatress of the Court, and disposed of places and Government offices as she chose. Queen Anne finally revolted, and this singular woman lived for many years in complete retirement, possessor of enormous wealth.

Marlowe, Christopher
b. Canterbury, Feb. 1564. d. London, June 1, 1593.

A shoemaker's son, he managed to equip himself at Cambridge University. When he reached London, he found the stage encumbered with "a litter of rude, rhyming farces and tragedies." These his mighty talent swept away. Like many another genius, he led a wild, erratic life, which fact makes it the more striking that in the few years at his disposal he should have produced so much work of brilliant quality. He prepared the way for the tragedies of Shakespeare, on whose early work his influence is clearly traceable. Marlowe met his death in a street brawl at Deptford.

Marvell, Andrew
b. Winestead, Yorks, March 31, 1621. d. London, Aug. 18, 1678.

After graduating at Cambridge, and spending four years in travel on the Continent, he became, upon Milton's recommendation, tutor to Cromwell's ward. Subsequently he was appointed

Milton's assistant in the Latin secretaryship. He sat in Parliament, and undertook with success certain diplomatic missions. His claims to fame, however, rest upon his friendship with Milton, his brilliant satires, and his poems. He was practically the first to recognise and proclaim the magnificent genius of "Paradise Lost."

Mason, Sir Josiah
b. Kidderminster, Feb., 1795. d. near Birmingham, June 16, 1881.
Beginning life as a hawker, he was successively carpenter, blacksmith, house-painter, and carpet-weaver. He discovered a way to make split key-rings by machinery, and then set up in business as a penmaker. He made the pens which became famous as Perry's, the name of the London stationer who sold them. Mason engaged in other considerable enterprises, and retired with a great fortune, nearly the whole of which he devoted to philanthropies, whose benefits should long be enjoyed.

Maurice, John Frederick Denison
b. near Lowestoft, Aug. 29, 1805. d. London, April 1, 1872.
As a Dissenter, he quitted Cambridge without taking a degree; but under the influence of Coleridge he went to Oxford, and took orders. Becoming the leader of the Christian Socialist movement, he exercised great influence throughout the country. He was the founder of, and taught in, the Working Men's College and the Queen's College for Women. He held various livings and professorships.

Maximilian I.
b. March 22, 1459. d. Wels, Austria, Jan. 12, 1519.
The son of Frederick III., this great German Emperor was elected Emperor of the Holy Roman Empire, and greatly extended the area of his dominions. Wars occupied a considerable part of his reign, but his ideal was peace. In his day learning flourished, the administration of justice was improved, and he gave cordial encouragement to the pursuit of arts.

Maxwell, James Clerk.
b. Edinburgh, June 13, 1831. d. Cambridge, Nov. 5, 1879.
After a successful career at Cambridge University, he became first occupant of the Chair of Experimental Physics established there by the Duke of Devonshire. He held other professorships, and was one of the greatest and best-loved teachers of his age. Although he lived only forty-eight years, thirty-three of those years were precious to science. His first scientific paper was read before a learned society when he was only fifteen. The greatest work of his life, his "Electricity and Magnetism," was justly regarded as the "Principia" of the nineteenth century.

Mazzini, Giuseppe
b. Genoa, June 22, 1805. d. Pisa, Italy, March 10, 1872.
He was one of the national heroes called to act with spirit and determination in the hour of Italy's greatest depression and degradation. Well educated and a fiery enthusiast, he first associated himself with secret societies, but, abandoning these, set on foot the Young Italy movement, whose watchword was "God and the People." He was banished from Italy, from France, and from Switzerland; but returned to his native land, to be appointed, with Saffi and Armellini, one of a triumvirate with dictatorial powers. Overpowered by the troops of Napoleon III., he had again to flee. After that, though his life was still eventful, he no longer played a really important part in Italian history. He had already earned the gratitude of his countrymen in firing them with hope and courage to strive for the unity which they were enabled to gain.

Mencius
b. Tsow, China, 372 B.C. d. China, 289 B.C.
The lineal descendants of this Chinese philosopher are said still to live in his native province. His teachings are studied by every scholar in China. When forty years of age, after a diligent study of Confucius, he went forth on a twenty years' pilgrimage, seeking a prince who would give effect to his system of social and political order. His system recognised the innate good of man, and desired a form of government which should do the greatest good to the greatest number. His quest was unsuccessful, and he retired with his disciples, never again to emerge into active life.

Mendelssohn-Bartholdy Felix
b. Hamburg, Feb. 3, 1809. d. Leipzig, Nov. 4, 1847.
The name of this composer was built up in three stages. His grandfather, Moses Mendelssohn, the philosopher, was born Mendel; his father added the Bartholdy to the already lengthened name. Mendelssohn was a wonderful boy, and before he was twenty had earned lasting fame. Hamburg and Berlin did not adequately honour him; London did. He loved England all his days, and produced here some of his finest work. His "Elijah" was first given at the Birmingham Festival. A Scottish tour inspired the "Hebrides" overture and the Scotch Symphony. "St. Paul" was given at Birmingham after having been produced at Düsseldorf, where for three years he held an appointment. His years, all too few, were singularly productive. At sixteen he gave the world that almost unequalled example of early musical talent, the overture to the "Midsummer Night's Dream." His last great work was the "Elijah." Two other oratorios which he had begun were left unfinished. Mendelssohn was a fine instrumentalist, a talented painter, and a charming correspondent.

Meredith, George
b. Hampshire, Feb. 12, 1828.
His early education was received in Germany, where, taken as a child, he remained until he was fifteen. Returning to England, he vainly endeavoured to interest himself in the law. Literature was his natural avocation. It was as a poet that he first courted attention. Afterwards he entered journalism, edited an Eastern Counties' paper, and acted as special correspondent for a London daily during the Austro-Italian War. For some little time he edited a review while Mr. John Morley, its regular editor, was absent in America; and for years he was the valued literary adviser to a publishing house. His introduction proper to the world of letters came with the "Shaving of Shagpat," followed, three years later, by the triumphant appearance of "The Ordeal of Richard Feverel." But it was his "Diana of the Crossways" which announced to the greater world—that world beyond the discerning few—that a new power had arisen—a new man come to the head of contemporary novelists. The list of his publications—fiction and verse—is too long for enumeration. His work leaves him one of the giants of nineteenth-century literature. In his old age he considerably altered some of the best of his early work. His place in the hierarchy of literary immortals is assured; but he will be judged on the earlier and better versions, which in his declining days he damaged in the attempt to improve.

Michelangelo
b. Caprese, Italy, March 6, 1475. d. Rome, Feb. 18, 1564.
It used to be considered beneath the dignity of a nobleman to learn to read and write. The father of Michelangelo—whose full name was Michelangelo Buonarroti—looked with disfavour on his son's taste for drawing, deeming art unworthy of a gentleman. But the boy, who was destined to wear the four crowns of sculpture, architecture, painting, and poetry, was permitted to follow his natural bent, and in due course was apprenticed to a painter. Soon came the opportunity to develop his love for sculpture. Michelangelo's proficiency in this art led to his rival, Torregiano, smashing his nose with a mallet. By the time he

had reached his thirty-first year he was famous as sculptor and painter, and was summoned to Rome to undertake the vast tomb of the Pope, Julius II. He was destined never to finish it. For forty years, off and on, he returned to what he felt was the work of his life, but all was vexation. Conspiracy and other influences caused his energies to be diverted into different channels. One of these led to his producing that world-wonder, the fresco decoration of the Sistine Chapel, a stupendous work, done entirely by his own hand after ver four years' labour. After the death of Julius he returned to Florence, where he produced some of his most famous statues. Again he was torn from his work—this time to organise the fortifications of Florence, in the defence of which, against the Medici princes, he took a foremost part. Again he went to Rome, wnere he designed the cupola of St. Peter's. He laboured to the last at his gigantic tasks. There never was a greater genius, there never was a more indefatigable man; and it was his boast to the end that he was ever a student. "I am still learning," he said shortly before he died. Had he never painted a picture, he would have been immortal as a sculptor; had he never seen marble, his fame as a painter would have endured as long as history; had he neither painted nor carved, he would live as a poet. His influence on the whole realm of art has been little, if at all, inferior to that produced on the realm of thought by Homer and Dante.

Mill, John Stuart
b, London, May 20, 1806. d. Avignon, France, May 8, 1873.

The childhood of the "Saint of Rationalism," as Gladstone called him, has no parallel. His father made him an intellectual machine. At three he was studying the Greek alphabet; at eight, mastering the classics in the original; at twelve, besides studying Euclid and algebra, he was acting as instructor to the younger members of the family. When only thirty years of age, he was given charge, in the India House, of all the Company's relations with native states; and it eventually fell to him to prepare the case against the transfer of the government of India to the Crown. The transfer having been effected, he retired, amply compensated, and had time to turn his attention to philosophical studies. He debated and wrote and collected data, with a view to writing a history of the French Revolution. Finding that Carlyle was engaged upon a similar task, he generously handed over to him all his materials. It was to Mill that Carlyle lent the manuscript of his first volume of the "History." A careless maid burnt it, to the infinite distress of poor Mill and the nobly-borne agony of Carlyle. Mill made amends, when the book did appear, by writing a brilliant review of it, at once focussing public interest upon it. After some years of quiet work, Mill produced the works on logic, government, and political economy, upon which his fame is based. He sat for some years in Parliament; but the life, though patiently endured, was not to his liking, and he accepted his ultimate defeat with perfect composure. His contributions to logic and political economy have greatly advanced and popularised those subjects, and widely influenced modern political thought.

Millais, Sir John Everett
b. Southampton, June 8, 1829. d. London, Aug. 13, 1896.

He began his career as a student at the Royal Academy when only eleven, and at seventeen first exhibited a picture. With Hunt and Rossetti he formed the Pre-Raphaelite Brotherhood, which aimed at painting Nature as she presents herself rather than as the artist may choose to idealise her. He was excellent in portraiture, landscapes, and general paintings. Engravings and other reproductions have made his pictures famous all over the world. Millais, who married the lady who was first the wife of Ruskin, was made a baronet, and was one of the most popular men of his time.

Miller, Hugh
b. Cromarty, Oct. 10, 1802. d. near Edinburgh, Dec. 23, 1856.

One of Nature's gentlemen, he was a working stonemason, who distinguished himself first as a poet, then as a capable writer on religious and political subjects. His work in geology made him still more famous. Overwork ruined his health, and he committed suicide.

Millet, Jean Francois
b. Gruchy, France. Oct. 4, 1814. d. Barbizon, France, Jan. 20, 1875.

He was the farm labourer who became a great painter. The friendship of a discerning patron enabled him to acquire an artistic education, and a portrait sent to the Salon gained him fame. He fought in the Revolution of 1848, then settled down among the peasants and painted their life. His famous picture, "The Angelus"—of which thousands of copies are to be seen—sold, not many years after his death, for over £23,000.

Milton, John
b. London, Dec. 9, 1608. d. London, Nov. 8, 1674.

The Miltons were of Oxfordshire yeoman stock, but the poet's father, having become a Protestant, was compelled to settle in London and earn his livelihood as a scrivener. Milton went to Cambridge as a pensioner, and at twenty-four settled down for six quiet years under his father's roof, determined to consecrate his life to poetry. Here he produced "L'Allegro," "Il Penseroso," and "Lycidas." A tour of sixteen months on the Continent followed. He was recalled by a sense of duty. His country was on the eve of the Civil War, and he felt that he could not rest away while such serious conditions ruled. He acted as pamphleteer, and afterwards as Secretary for Foreign Tongues to the Commonwealth. When the Protectorate fell, Milton's prosperity was at an end and his safety endangered. Blindness attacked him at forty-four, and to the end of his days he had to depend upon the help of others. "Paradise Lost" was published in 1667, and, all told, brought the poet what in our money would amount to £70. He sold the copyright for £5. "Paradise Regained" and "Samson Agonistes" came out simultaneously four years before his death. He was thrice married, and, though he never actually knew the pinch of poverty, he was very poor in this world's goods for one so great. Fame had come to him before he died, but it was after his death that the world realised the mighty genius of the man who ranks with Homer, Dante, and Shakespeare as the greatest poet this world has seen. A blessing in disguise was the law of Laud, which forbade Milton's entering the Church as once he wished. He might have become a great prelate, but England would have lost the one great singer before whom only Shakespeare stands.

Moffatt, Robert
b. Ormiston, Scotland, Dec. 21, 1795. d. near Tonbridge, Kent, Aug. 9, 1883.

It was while working as an under-gardener that he studied for the missionary field. He devoted himself mainly to Bechuanaland, into the language of which country he translated the Bible. For half a century he laboured nobly in the wilds of the Dark Continent. Livingstone became his son-in-law.

Molière, Jean Baptiste
b. Paris, Jan. 15, 1622. d. Paris, Feb. 17, 1673.

Jean Baptiste Poquelin assumed the name by which he is known to all the world when he went upon the stage. This step in life he took after having studied under the Jesuits and read for the law. To the end of his days he devoted himself to writing plays and acting in them. He remains a colossal figure in French drama and poetry. To him the stage was always a lay pulpit; its aim not merely amusement, but reformation of manners by means of amusing spectacles. Ruskin shows how,

living in the blindest period of the civilised world's history, in the most luxurious city, and the most corrupted Court of the time, he yet manifests through all his writings an exquisite natural wisdom, a capacity for the most simple enjoyment, a high sense of nobleness, honour, and purity; and that, in all he says of art and science, he has an unerring instinct for what is useful and sincere, and uses his whole power to defend it.

Moltke, Helmuth Karl Bernhard, Count von
b. Parchim, Germany, Oct. 26, 1800. d. Berlin, April 24, 1891.
He began his military studies in Denmark, and entered the Danish Army. Transferring his services to the army of Prussia, he devoted his energies to raising that army to first-class rank. He was the chief strategist in the war against Denmark, in the Austro-Prussian War, and the Franco-Prussian War, and, with Bismarck, helped to make Germany a nation. His friends knew him as "the Silent." He was among the most modest of men, and added to supreme genius for war the capacity for unweariedly taking pains.

Montaigne, Michel Eyquem de
b. near Bordeaux, France, Feb. 28, 1533. d. near Bordeaux, Sept. 13, 1592.
The father of the modern essay was trained as a boy in Spartan ways. He was liberally educated, but treated as if he were one of the poor. This was in order that he might realise and sympathise with the lot of the humblest. Some years were passed at Court, and some devoted to extensive travels in Europe. He returned to France unwillingly, to accept the office of Mayor of Bordeaux, and discharged the duties of the office while inditing his immortal essays. These had enormous influence on the great men of his own and later ages. He examined all questions in the spirit of the sceptic; but upon his deathbed he devoutly received the last rites of his Church.

Montesquieu, Charles de Secondat
b. near Bordeaux, Jan. 18, 1689. d. Paris, Feb. 10, 1755.
Proceeding from college to the study of law, he first claimed attention by his clever criticism of the France of his day. This gained him election to the French Academy. After a spell of travel he settled down to the work of his life, of which the outstanding productions were his examination into the causes of the greatness and decline of the Romans, and his great work on the Spirit of Laws. To the latter task he devoted fourteen years. Although it was placed on the Index, it passed through twenty-two editions in the course of a couple of years, and had an enormous influence on the spirit of the age. Always a victim of weak sight, he became totally blind towards the close of his life.

Moore, Thomas
b. Dublin, May 28, 1779. d. near Devizes, Wilts, Feb. 25, 1852.
The son of an Irish grocer, he became one of the most popular poets and satirists of his time. Appointed to a sinecure post in Bermuda, he selected as his deputy a man who eventually misappropriated £6,000, which sum Moore repaid. His publishers, with unbounded faith, promised him £3,000 for his "Lallah Rookh," then unwritten; and though he offered to release them from their bargain, in consequence of the bad times, they held to, and profited by it. He made a handsome income, but was always poor, in spite of the providence of a model wife. He wrote the biography of Byron, and in turn had his own works edited by one of England's Prime Ministers —Lord John Russell.

More, Sir Thomas
b. London, Feb. 6, 1478. d. London, July 6, 1535.
Educated, as his father had been, to the law, he at one time seriously thought of turning monk. Statecraft later claimed his attention, and he became successively member of Parliament, Ambassador, Speaker of the House of Commons, and, in succession to Wolsey, Chancellor. He defended the Papacy against Martin Luther, and opposed the attack of Henry VIII. on the Church and his projected divorce of Catherine. Declining to swear adherence to the Act which vested the succession in the issue of Anne Boleyn, he was arrested and beheaded. Most famous of all his works is his "Utopia," in which he outlines a model community where all share the labours and rewards of an ideal life.

Morland, George
b. London, June 26, 1763. d. London, Oct. 27, 1804.
The history of genius has few sadder pages than that on which is inscribed the life story of this great artist. He worked, not for love of his art, but solely to get money with which to gratify sordid passions. He died miserably in a sponging-house. One of the finest of his works is in the National Gallery, and every year his pictures are increasingly esteemed.

Morley, John
b. Blackburn, Lancs, Dec. 24, 1838.
His father, like his elder brother, was a surgeon. On going to Oxford, he seems to have cherished the notion of entering the Church. In later years his views became pronouncedly agnostic. His earlier career in London was a struggle for footing in literature. He did not scorn the humblest work, but what he did he did well. Since then he has edited the "Fortnightly Review," the "Pall Mall Gazette," and two notable series of books. His own contributions to literature have included biographies of Burke, Voltaire, Rousseau, and Gladstone. The latter is a noble monument to a great statesman, nobly done by a scholar and loving friend. He has twice acted as Secretary for Ireland, and, upon Sir Henry Campbell-Bannerman becoming Prime Minister, was appointed Secretary for India.

Morris, William
b. Walthamstow, Essex, March 24, 1834. d. London, Oct. 3, 1896.
Painting was his first love, but poetry next claimed him for her own. He wrote many beautiful original poems and some striking translations, and set forth his Socialistic ideals in fine, nervous prose. He and a few kindred souls established a manufactory of artistic wallpapers, stained glass, pottery, and other articles of domestic use. The scheme was fanciful, but it had a great effect in reforming the taste of the country.

Morse, Samuel Finley Breese
b. Charlestown, Mass., April 27, 1791. d. New York, April 2, 1872.
The son of a clergyman, he graduated at Yale, and visited England to study portraiture under West. His efforts in art were unsuccessful in his native land, but his scheme for the electric telegraph well justified his existence. He conceived the idea in 1832, but not until fifteen years had elapsed could he induce the Government to establish a trial line between Baltimore and Washington. There was a dispute as to priority of discovery between the partisans of Morse and Wheatstone, but Morse deserved the honours which crowned his closing years.

Mozart, Wolfgang Amadeus Chrysostom
b. Salzburg, Austria, Jan. 27, 1756. d. Vienna, Dec. 5, 1791.
The world has never produced a greater musical genius than Mozart, and never treated another so badly. When he was a tiny child, all Europe was wildly enthusiastic over his marvellous abilities as instrumentalist and composer. By the time he had reached the age of twenty he had learned all that there was to be learned about music, and had to his credit many compositions which still live. But it was not easy to repeat the successes of his childhood. His genius, now fully matured, expressed itself in an unparalleled flood of musical glories. To every form of music he contributed superb works—opera, mass, symphony, concerto, sonata, song. All this time he was fighting for a bare livelihood for himself and his young wife. The greatest master of music in the history of the world had to look to lessons for his bread. It was

while his crowning work, "The Magic Flute," was being played that he received a mysterious order to compose a "Requiem." It was to be ready in a month. His breaking health sank under the manifold taxes to which he submitted himself. He declared that the work would be his own requiem, and it was. He died while still labouring at it. His death was one of the most pathetic in history. He was hurried into a pauper's grave, and to this day no man can say where his poor bones lie.

Murchison, Sir Roderick Impey
b. Tarradale, Ross-shire, Feb. 19, 1792. d. London, Oct. 22, 1871

Trained in a military academy, he entered the Army and fought in the Peninsular War. Exchanging into another regiment, in order to see more active service he was disappointed, but had the good fortune to meet the lady who became his wife and inspired his whole life's work. His geological discoveries, especially his establishment of the Silurian System, made him famous. It was he who, observing the resemblance between the Ural Mountains and the Australian chains, first predicted the discovery of gold in Australia.

Murdock, William
b. Auchinleck, Ayrshire, Aug. 25, 1754. d. Birmingham, Nov. 15, 1839

His father—who had been a gunner, but took up the trade of a millwright on returning to civil employment meant the future inventor to follow his own trade. Luckily, the youth found employment with Boulton & Watt at Birmingham, and was given responsible work in Cornwall, where the firm had important machinery plant. Here Murdock invented various improvements for the steam-engine. His most important discovery, however, was the distillation of illuminating gas from coal, wood, and peat. He lighted up his master's premises with the new illuminant in 1803, some years after he had begun experiments at his own house. His fame is overshadowed by that of the great men he served, but he was a man of striking original powers.

Murillo, Bartolomé Estéban
b. Seville, Spain, Jan. 1, 1618. d. Seville, April 3, 1682.

Humbly born, he owed his instruction in art to an uncle. When twenty-two, he had the good fortune to gain an introduction to Velasquez, who gave him an introduction at Court, which served to secure him ample patronage. His work was nearly all of an intensely devotional character, expressive of his own pious devotion. He married a wealthy wife, and enjoyed great prosperity. His death was brought about by a fall from a scaffolding while he was painting in a church in Cadiz. Some two hundred of his works are in England.

Murray, John
b. Edinburgh, 1745. d. November 6, 1793.

He joined the Royal Marines when seventeen years of age, but, disgusted with the monotony of the life, retired on half-pay at twenty-three, and turned bookseller. From the little business which he set up grew the world-famous publishing house of John Murray. The prosperity of the business was established by his son, John Murray II. (b. Nov. 27, 1778; d. June 27, 1843)—the "Anak of publishers," as Byron called him. He it was who started the "Quarterly Review," and paid Byron £20,000 for his works.

Musset, Alfred de
b. Paris, Dec. 11, 1810. d. Paris, May 1, 1857.

After a brilliant college career, he made a name for himself in literature at twenty, and followed with poems, comedies, tragedies, and short stories. Some of his poetry is perfect, but his work was unequal—a fact attributable largely to his irregular life.

Nansen, Fridtjof
b. near Christiania, Norway, Oct. 10, 1861.

He studied at the Universities of Christiania and Naples, and celebrated his majority by making his first voyage into the Arctic. A second followed seven years later, when he and five comrades crossed Greenland from east to west. This nerved him for his greater effort, the famous voyage in the Fram, when, in a three years' expedition—during which he permitted his ship to be frozen in, and to drift with the set of the ice—he succeeded in getting nearer to the North Pole than anyone else had previously done. Upon his native Norway being separated from Sweden, he was appointed first Ambassador of the new Power to England.

Napier, John
b. Edinburgh, 1550 d. Edinburgh, April 4, 1617

He was born when his father was less than seventeen years of age. Like his sire, he was keenly interested in scientific agriculture. In abstract science, however, lay his chief glory. His genius expressed itself in devising methods for lessening the labour of reckoning. His famous logarithms and the device known as "Napier's bones" were the concrete results of his genius by which he is best remembered. His discoveries were of vast importance to astronomy, navigation, surveying, and other pursuits involving complicated and elaborate calculations. His eldest son was ennobled.

Napoleon Bonaparte
b. Ajaccio, Corsica, Aug 15, 1769. d. St. Helena, May 5, 1821.

He was the second son of Carlo Bonaparte, who was of noble but impoverished family. His military studies began at Brienne, and were continued at Paris; but actual experience began in his seventeenth year, when he obtained a lieutenancy in an artillery regiment. The disturbed state of the nation, and the urgent need for officers with talent, made his promotion rapid. After commanding the Siege of Toulon against the Royalists, he was made a general, when only twenty-four. In another three years he was the most famous general in Europe. He married Josephine, a wealthy widow of much influence in Paris, and immediately set out for Italy, where he defeated the Austrians and Piedmontese, and entered Milan. Returning to France with the bays of many victories, he next entered upon a campaign against the eastern dominions of Britain. He conquered Egypt and Syria, but met with a reverse at Acre, where the defence was assisted by the English. Recalled to France by disturbing news of political disruption and of the loss of the newly-gained Italian territory, he was elected First Consul for ten years. Then, crossing the Alps, he swept down on Italy, and inflicted crushing blows upon the Austrians, winning for France the whole of Northern Italy. Various treaties gave the continent temporary peace, and Napoleon took advantage of it to reorganise France by means of the Code Napoleon, the establishment of the University, the National Bank, the Legion of Honour, and by the sweeping away of abuses which the Revolution had left. These were fruitful days, but war soon broke out again. He made elaborate preparations for the invasion of England, and even had a medal struck to commemorate the triumph which he was never to achieve. The Battle of Trafalgar effectually settled the question of invasion. Thereupon he turned his armies to Germany, where the tremendous victories of Ulm and Austerlitz were gained, to be followed by the overthrow of Prussia at Jena. He had now become hereditary Emperor, and attained the zenith of his power. One of his brothers was King of Naples, another was King of Holland, and a third was King of Westphalia. He himself was crowned King of Italy, and he now set his brother Joseph on the Spanish throne. The people rose in revolt. Wellington landed in Portugal, and the Peninsular War was begun. Many troubles now gathered about him; but after further battles he concluded peace with Austria, and married the daughter of her Royal house, having previously divorced

Josephine. Meanwhile, the Continental system—by which the commerce of England was to be boycotted—was in force, and it was the failure of the Tsar strictly to enforce it which led to war with that country. Napoleon marched a vast army to Moscow, but the city was fired, and he had to retreat in the depth of a Russian winter, harassed all the way by an indomitable foe. He lost four-fifths of the army with which he had set out, and, the allied armies of his enemies closing in upon Paris, he was compelled to abdicate. For a few months he lived as King of the Island of Elba, but returned secretly to France, regained the throne, and began the hundred days which ended in his final overthrow at Waterloo. He was taken prisoner to St. Helena, and died there, after five and a half wretched years, of cancer. Napoleon was the incarnate spirit of war, but he was great as an administrator. That he was cruel, and false, and treacherous, and filled with inordinate vanity, which cost the lives of millions of his fellow-creatures, every student of his history is aware. But such a man is not to be judged by ordinary standards. As Lord Rosebery has said, Napoleon came from Corsica a little pagan, viewing the world as his oyster. He was reared in the life of camps and in the terrors of revolution. He was raised to rule a nation which, in the horrors of a great convulsion, had formally renounced and practically abjured Christianity. He had to fight for his own hand against the whole world. It was breathless work, which gave little time for reflection. Before he died he saw all that he had built at such a cost of blood swept away. Had he died Emperor of France, no man could have followed him. His death must have created a gulf in which the whole apparatus of his government would have disappeared.

Nasmyth, James

b. Edinburgh, Aug. 19, 1808. d. London, May 7, 1890.

The Nasmyths were a talented family—the father a gifted portrait painter, a brother a landscape artist. James Nasmyth was the mechanical genius of the family. In 1839 he was informed that a steamship could not be built because there was no forge in existence big enough to forge its paddle-crank. In half an hour Nasmyth sketched his famous steam-hammer. The contrivance was built from that hurriedly-drawn sketch. He afterwards invented the steam pile-driver. Astronomy was one of his favourite studies, and he wrote a volume on the moon, which is still reprinted.

Nebuchadnezzar

began to reign, Babylon, 604 B.C. d. Babylon, 562 B.C.

As a warrior, architect, engineer, and ruler, Nebuchadnezzar was supreme in his age. He inherited from Nabopolassar, his father, a mere provincial city in Babylon. He made the city the wonder of all the ages; his dominions he so enlarged that they extended from Persia to Egypt, from Cicilia to the Persian Gulf. He besieged Jerusalem, and twice carried away its king, and swept all but the very outcast of the people into captivity. The rebellion of the Jews he punished with atrocious cruelty. Zedekiah—whom he had placed on the throne, but who had risen against him—he condemned to gaze on the slaughter of his own children. Then he put out his eyes, and led him in chains to Babylon. When Daniel interpreted his dreams he worshipped him, and bade all his people worship no god but the God of Daniel. For seven years his mind was clouded; but, recovering, he seems to have forsaken idolatry. His empire decayed after he died as rapidly as he had built it.

Nelson, Horatio, Viscount

b. Burnham Thorpe, Norfolk, Sept. 29, 1758. d. Trafalgar, Oct. 21, 1805.

A son of the rectory, he was a weakly boy, who never seemed likely to make a sailor; but experiences in the West Indies, and an expedition to the Arctic Regions, proved his metal. He was a post-captain at twenty-one, serving in the American War. War with France having been declared, he served under Hood and Hotham, and greatly distinguished himself at the battle off Cape St. Vincent, where for an hour his ship withstood the whole Spanish van and captured two vessels. Promoted to the rank of rear-admiral, he was sent to intercept Napoleon's expedition to Egypt. This he failed to do, but he came up with the French fleet in Aboukir Bay. The French were anchored in superior numbers, and Nelson planned a daring and original stroke. The wind was blowing against the French fleet, and he sailed down and took the enemy's ships one at a time. He captured or sunk all save four, which escaped, to be taken by him not long afterwards. Nelson went to Naples a hero. He had married some years before, but now he met Lady Hamilton at the Court of Naples, and they entered into that liaison which stains his name. He remained at Naples in defiance of orders, and when he reached England there was a stormy interview with his wife, after which they parted, never to meet again. He was censured for his disobedience at Naples, but there was too much fighting for him to remain idle. He directed the attack on Copenhagen and the Danish fleet, where he won new honours in a fierce and bloody battle. The after events in his life were but preliminaries to the Battle of Trafalgar. The French and Spanish fleets were allied; unless these were crushed, Napoleon's army would surely invade England. There were many delays and wearisome searchings by Nelson for the missing fleet. At last it was brought to battle off Cape Trafalgar. Nelson signalled to his fleet, "England expects that every man will do his duty." He had twenty-seven ships, the French and Spaniards thirty-three. The enemy's fleet was annihilated. Nelson himself fell, shot by a Frenchman in the tops of the Redoutable; but he lived long enough to know that his victory was complete and his country saved. He was the greatest naval warrior the world has known. He had all the genius and all the patience and the bravery essential to his work. In private he was a simple, unaffected man. In one battle he had an eye destroyed; in another he lost an arm; but he was always wholly a hero in battle. The one blot upon his fame is his relations with Lady Hamilton—a beautiful adventuress, who had become the wife of Sir William Hamilton. For her he sacrificed his personal honour and reputation as a moral man.

Newcomen, Thomas

b. Dartmouth, Feb. 1663. d. London (?), 1729.

He was one of the obscure, industrious geniuses to whom we owe the application of steam as a motive power. He was either an ironmonger or a blacksmith. Possessed of an original and inquiring mind, he corresponded with Robert Hooke as to the investigations of Papin and the Marquis of Worcester upon the applicability of steam-power for the purpose of driving machinery. He found a kindred spirit in Savery, a mine manager of Cornwall, and a sympathetic friend in Cawley, a glazier. The former was another born inventor; Cawley seems to have advanced the capital which Newcomen first needed for his experiments. The outcome was a patent for the "atmospheric steam-engine." Its purpose was to pump water from mines. This was the first piece of mechanism in which steam was used with practical success. Hero, of Alexandria, born two thousand years before, had discovered the power of steam, and applied it in the form of what was practically a primitive steam-turbine. For two thousand years the secret lay hidden, if it can be said ever to have been mastered. Possibly Newcomen never heard of Hero. He, at any rate, was the next man after the Alexandrian genius successfully to carry out experiments with steam. But Newcomen turned his experiments to practical account, and all our triumphs with steam date from his successful efforts.

Newman, John Henry
b. London, February 21, 1801. d. Birmingham, August 11, 1890.

The son of a banker, whose affairs became involved before the future cardinal had completed his Oxford course, he gained an Oriel Fellowship and took Orders. He threw himself with eagerness into the "Tractarian Movement" at Oxford, which landed him, as it had landed others, in the Roman Catholic Church. In his new faith he worked humbly and with zeal, and became famous for his sermons and lectures and writings. He had a singularly charming literary style, and was a poet of high order. His "Lead, Kindly Light" is the most popular of all hymns; his "Dream of Gerontius" is a work of striking beauty. He was created a cardinal in 1879, thirty-four years after his secession from the Anglican Church. His brother, Francis William Newman, was an educationist of renown, and did not follow John Henry to Rome.

Newton, Sir Isaac
b. Woolsthorpe, Lincs, December 25, 1642. d. London, March 20, 1727.

His father was a small freehold farmer. He was only twenty-one when he took his B.A. at Cambridge, and recorded his discovery of fluxions. A year later the great law of universal gravitation dawned upon him, suggested to his mind by the fall of an apple. His efforts to explain the lunar and planetary motions were fruitless, owing to the absence of reliable data as to the size of the earth, and he had to put aside his work, and turn to the investigation into the nature of light and the construction of telescopes. His discoveries as to the latter led to the construction of the first reflecting telescope, which later workers were to bring to perfection. Picard produced his estimate of the size of the earth in 1670, and Newton was able to resume, at the point where he had desisted, his speculations on the law of gravitation. Fourteen years elapsed before his completed theory was given to the world. Newton sat in Parliament, became Master of the Mint, and reformed the coinage; recommended public encouragement for an invention to determine longitude, and was for twenty-four years President of the Royal Society. He has been called the priest of Nature. No one before him had ever so clearly unfolded the laws by which the material world is regulated. He was one of the humblest of men, and spoke of himself as a child in knowledge.

Nightingale, Florence
b. Florence, May 15, 1820.

Although born in Florence, she is of English parentage. When quite a young woman, she made a tour of European hospitals, and on the outbreak of the Crimean War volunteered to organise a nursing department at Scutari. The terrible condition of the wounded was vastly improved under her skilful and sympathetic direction, and her work was the beginning of complete reforms in Army hospital methods. A public testimonial took the form of a £50,000 gift to her. This sum she devoted to the formation of a properly-equipped training institution for nurses.

Otho I. or Otto the Great
b. 912. d. Memleben, Germany, May 7, 973.

Succeeding his father, Henry I., as King of the Germans, he extended his dominions in various directions, suppressed rebellious nobles, restored the institutions of Charlemagne, and implanted Christianity in Scandinavian and Slavonic lands.

Owen, Sir Richard
b. Lancaster, July 20, 1804. d. London, December 18, 1892.

After study in Edinburgh and at a London hospital, he determined to enter the Navy. While hoping for an opening, he was offered the post of assistant to the curator of the museum of the Royal College of Surgeons. Here was housed the great collection got together by John Hunter, and it became Owen's task to classify and catalogue it. So, quite by chance, he was led to devote himself to science, and to make a lasting reputation as one of the foremost of British comparative anatomists and palæontologists. His work, slow to be recognised in official circles by his own countrymen, was honoured by every scientific academy in Europe.

Owen, Robert
b. Newtown, Wales, May 14, 1771. d. Newtown, November 17, 1858.

The founder of Socialism in Britain was the son of poor parents, and from the position of shop-boy rose to that of factory manager, and then cotton millowner. He put his Socialism to practical test by experimental plans in Scotland, America, Ireland, and England. The scheme, though it attracted widespread attention, was not a success, and brought him to comparative poverty. Nevertheless, he was instrumental in bringing about the first factory legislation. He was the pioneer of the co-operative movement, and schools for infants had their origin in his experiments.

Paganini, Niccolo
b. Genoa, February 18, 1784. d. Nice, May 27, 1840.

The prince of violinists was the son of a street-porter, who scourged him to study while yet an infant. He was performing in public at nine, and at seventeen was a blasé man of the world—a gambler and spendthrift. Then he disappeared for four years from public life, emerging at the age of twenty-one, to win triumph upon triumph in all the capitals of Europe. Gaunt and repellent of appearance, playing the violin with demonic force and spirit, and with effects such as no other man had ever produced, he exercised upon his audiences an influence quite hypnotic. Serious people in polite society declared that he was animated by evil spirits, and that he was accompanied on the concert platform by a "familiar." He made a large fortune, but lost heavily over speculations.

Palestrina, Giovanni Pierluigi da
b. Palestrina, Italy, about 1524. d. Rome, February 2, 1594.

It was to Palestrina that the Council of Trent entrusted the reform of Church music. He was the first to combine the art with the science of music, to give beauty as well as technical correctness. His work marked a new epoch in music.

Paley, William
b. Peterborough, July 1743. d. Lincoln, May 25, 1805.

After a successful career at college, he held various benefices, but was remarkable more for his writings than his spoken sermons. His principal work was the well-known "Evidences of Christianity."

Palissy, Bernard
b. near Agen, France, about 1509. d. Paris, 1589.

Industrial inventor, philosopher, and scientist, Palissy was one of the heroes of his century. His long and undaunted struggles with poverty while trying to discover the secret of the enamel for china are of the classics of industral history. Imprisoned as a Huguenot, he was released to continue his public works, but was again thrown into the Bastille because of his religion, and died in that infamous prison.

Palladio, Andrea
b. Vicenza, Italy, November 30, 1518. d. Vicenza, August 19, 1580.

The author of the Palladian style of architecture was the creator of many noble works in Italy, and the founder of the modern school of Italian architecture. He wrote as well as he designed, and his great book on architecture was of inestimable assistance, among others, to Inigo Jones, the great English architect.

Papin, Denis
b. Blois, France, August 22, 1647. d. London, 1712.

Regarded by the French as the inventor of the steam-engine and steam navigation, he certainly was one of the pioneers in these directions. He

did apply steam for driving a piston, but he looked not to the expansive force of steam, but to atmospheric pressure for mechanical power. His idea was developed by Newcomen, Brindley, and Smeaton, and undoubtedly paved the way for work upon more correct lines. Papin did important work in association with Huygens and Boyle, and set convention at naught by fitting a paddle-wheel worked by hand into a vessel in which he essayed to cross the Channel. He died in poverty and obscurity.

Paracelsus

b. Switzerland, December 17, 1493. d. Salzburg, September 23, 1541.

Paracelsus was the self-conferred name of Theophrastus Bombastus von Hohenheim, son of a Swiss physician; he early studied alchemy and chemistry, and by practical experiments learned the properties of metals and minerals. He was a vain-glorious creature, but the courage with which he advocated his theories was of great importance in affording a new impetus to the development of pharmaceutical chemistry and in encouraging research and investigation. From his labours many new chemical compounds were discovered.

Park, Mungo

b. Selkirkshire, September 10, 1771. d. Africa, 1805.

At twenty years of age, after having studied medicine and surgery, he set sail for Sumatra in the East-Indiaman *Worcester*, on which he held the post of assistant-surgeon. This led to his employment by the African Association, in whose behalf he undertook to explore the course of the Niger. After many startling adventures he returned to civilisation, and, in an interesting volume, threw light on the interior of the Dark Continent. Thereafter he settled down to practise as a country surgeon in Scotland. The life, however, proved impossible to him, and he again undertook an expedition into the interior of Africa. Starting from Pisania, on the Gambia, he lost thirty-eight of his forty-five companions. The survivors were attacked by natives at Boussa, and perished with him.

Pascal, Blaise

b. Clermont-Ferrand, France, June 19, 1623. d. Paris, August 19, 1662.

His father, early persuaded of the talents of the boy, gave him an excellent education, but kept him from the study of mathematics, to which he particularly inclined. In spite of this deprivation Pascal became one of the greatest mathematicians of his age, and is said to have "reconstructed" geometry while still a boy. He wrote, before the completion of his sixteenth year, a treatise on "Conic Sections," which attracted the attention of Descartes; and before he was nineteen had invented a calculating machine to help his father in his work. His investigations in connection with the vacuum and hydraulics were of great importance. His literary productions were of two kinds—scientific and philosophic, moral and theological. His "Provincial Letters," a satire on the moral theology of the Jesuits, and "Thoughts" are for all time. They had an extraordinary effect in Europe at the time of their production, and are still treasured by every people into whose language they have been translated.

Pasteur, Louis

b. D^le, France, December 27, 1822. d. St. Cloud, France, Sep. 28, 1895.

He was the son of a tanner, and when homesick and melancholy would say, "If I could only smell the tannery again I should be well." None of the early manifestations of genius which often foreshadow coming greatness was apparent in his case. His health was poor, and his mental faculties slow to develop. But he had industry and application, and, by working steadfastly at problems which had puzzled all the chemists and physicists of his time, made a discovery which at once placed him in a position of honour among contemporary scientists. This was the outcome of his work on tartrate crystals and "left-handed" tartrates, and led him on to his great discoveries in fermentation and the action of atmospheric organisms. He swept aside the chemical speculations as to spontaneous generation, and showed that wine and milk turn sour, and meat becomes putrid, from the effects of these atmospheric organisms. Exclude those, he said, and food and drink remain pure and sweet. It was not without the most delicate and intricate experiments that his point was proved. Once established, it effected a complete revolution in chemical and biological science. The way was prepared for Lord Lister and antiseptic surgery, and for a thousand-and-one applications of the discovery to commerce and food supply. By this time the tanner's son had established himself at the head of his calling. Many and severe tests were imposed upon him, but, thanks to his powers of patient research and quick and exact observation, he succeeded in all. He had never seen a silkworm until the silk-producers besought his aid in the extermination of a pest which was ruining their industry; but he stamped out the plague. He cured chicken cholera, which had been destroying 10 per cent. of the poultry of his country; and he reduced the mortality in anthrax from 10 to 1 per cent. These discoveries represented in money hundreds of millions of pounds. Even more important to the human race were his investigations as to the cause and cure of hydrophobia, which resulted in his finding a way of rendering dogs immune from the evil, and of curing human beings suffering from it.

Paul, St.

b. Tarsus, Cilicia. d. Rome, 64, A.D.

The son of Jewish parents, "a Hebrew of the Hebrews," he was named Saul, and put to the trade of a tent-maker. Going to Jerusalem, he studied under Gamaliel, who held a foremost place among the theologians of the city. Gamaliel was a broad-minded, tolerant man, but Paul imbibed only of his knowledge, not of his spirit, so that he became a great master of the law and traditions and precedents, and thoroughly acquainted with the Scriptures and current methods of interpretation. The future Apostle became prominent as a persecutor of the Jews, and was present at the stoning of Stephen. Then came his miraculous conversion, and his subsequent teaching and exposition of Christianity. He made missionary tours in Syria, Cyprus, Asia Minor, Macedonia, and elsewhere; was imprisoned and tried, appealed against his sentence, and was sent to Rome. There he was acquitted, so that he was able to resume his journeys, but, returning to Rome, suffered martyrdom under the brutal Nero. Avowedly the servant of Christianity, he was really its leader. For two centuries after his death his name was little regarded, though his work lived and flourished and extended. His position and labours became more fully recognised in the century of Ambrose, Athanasius, and Augustin, but it was reserved for later Christians to raise him to his right place in the rôle of priests and martyrs.

Paxton, Sir Joseph

b. near Woburn, Beds, August 3, 1801. d. Sydenham, June 8, 1865.

One of the best examples of the self-made man, Paxton began life as an ordinary working gardener on the estate of the Duke of Devonshire, for whom he modelled the famous Chatsworth gardens and conservatories. He sent in for competition a rough design for a building for the Great Exhibition in Hyde Park, which gained the prize. He saw the building erected, and afterwards transferred to Sydenham, where it exists still as the world-famous Crystal Palace. Paxton's useful and admirable life was crowned by the publication of several valuable horticultural works. As an instance of his powers of observation, it may be

noted that the excellence of his design for the Crystal Palace was its lightness and its grace of design. He adapted the idea from an aquatic plant on the Chatsworth estate.

Peabody, George

b. S. Danvers, Mass., February 18, 1795. d. London, November 4, 1869.

Starting on the lowest rung, he worked in various small shops as assistant to grocers, drapers, and storekeepers, until he had saved capital enough to become partner in a dry goods store. This was when he had attained the age of thirty-four. Eight years later he opened in London as a merchant banker. By unimpeachable methods he amassed a great fortune, and during his lifetime gave away one and a half millions for exploration, for education, and for the building of industrial homes in London. The Peabody buildings have been established out of the funds given by him for the purpose.

Peary, Robert Edwin

b. Cresson Springs, Penn., U.S.A., May 6, 1856.

The most persistent of Arctic explorers, he joined the American Navy in 1881, and from time to time has sought leave of absence to make "a dash for the Pole." He had done a good deal of survey and mapping work in silent lands and lonely waters, before the world at large heard of him, and thus prepared himself for the greater work with which his name was to become identified. In the expedition from which he returned in 1906 he got to within 200 miles of the Pole on the Greenland side, so eclipsing all existing records. The Abruzzi expedition went thirty miles nearer than Nansen's; Peary's got thirty miles beyond the point at which the Abruzzi expedition was driven back.

Peel, Sir Robert

b. near Bury, Lancs, February 5, 1788. d. London, July 2, 1850.

Consecrated to politics from his youth up, Peel was bidden by his father to aim no lower than the Premiership. "Bob, you dog, if you're not Prime Minister, I'll disinherit you!" his father used jestingly to say. But he was sworn to service with the wrong party. At heart a Whig, he was destined to lead, to break up, to reconstruct, and once more shatter the Conservatives. At twenty-four he was Chief Secretary for Ireland, and so hostile to Catholic claims for freedom that he was nicknamed "Orange Peel." Yet it fell to him, as Home Secretary, and Leader of the House of Commons, to propose to the House a Bill for Roman Catholic Emancipation, his earlier antipathy to which, he confessed, had been his sole reason for refusing to act with Canning. The Bill cost him his seat and broke up his party, though not at once. He carried several useful measures, of which his reform of the police force was the most conspicuous. As Leader of the Opposition during the next ten years he was brilliantly successful, and restored his party to power. On taking office as Prime Minister in 1841, he was supported by a Conservative party pledged to Protection, and it fell to him to destroy the system which he had been placed in power to maintain. He resigned, in order to allow Lord John Russell to sweep away the Corn Laws; but as Russell could not form a Government Peel returned, and himself abolished the taxes on food. His party revolted and defeated him, and he declared that he had done for all time with parties. His death, the result of an accident while riding, prevented his saying from being falsified. Although force of circumstances made him forsake principles to which he was pledged, the honesty and integrity of Peel are not to be impugned. The problem of his position was a difficult one, and was the more so from the fact that he never had a confidant in public life to trace the development of changes in his opinions. His youngest son became Speaker of the House of Commons in 1884, and held that position until 1895, when he was created Viscount Peel.

Penn, William

b. London, October 14, 1644. d. Ruscombe, Berks, July 30, 1718.

His father, the redoubtable Sir William Penn, sent him to Oxford, where he came under the ban of the powers for Nonconformity. Penn travelled, and took military service, but was recalled to his earlier ideas by a chance meeting with a Quaker minister, under whose influence he developed into a bold speaker and writer, carrying the war for freedom of conscience from England into Germany. Twice his free expressions of opinion brought him to gaol; but his trial in 1670 marked an epoch in English public life, in that it established for all time the immunity of juries. In 1681 he obtained from the Crown, in lieu of his father's claim upon it, a grant of territory in America called, after the admiral, Pennsylvania. Here he settled a numerous body of his co-religionists with a famous charter. He planned the city of Philadelphia, and became governor as well as proprietor of the colony. After the accession of William III., Penn was wrongfully accused of treasonable adherence to the deposed James II. His troubles were not ended, in the New World or the Old. The Colonial Constitution had proved unworkable, and there was much discontent. The colony did eventually prosper, but Penn, returning to England, suffered financial embarrassment, and was actually an inmate for nine months of the debtors' prison—the Fleet. To the end his life was harassed by pecuniary and political troubles. Penn is one of the men whose characters and actions Macaulay has wrongly appraised. The influence which he had at Court was invariably exerted for the succour of his persecuted brethren.

Pericles

b. Athens, 5th century B.C. d. Athens, 429 B.C.

Born of distinguished parents, Pericles was for forty years the leading statesman in Athens. In his day she reached her highest point in splendour and power. He obliterated all trace of oligarchical institutions; he made Athens an empire state; he took tribute of maritime allies, and devoted part of the money to the adornment of Athens with those glories which made the memory of the city immortal. To him she owed the Parthenon, Erechtheum, the Propylæa, the Odeum, and numberless other noble buildings, as well as some of her finest classical sculptures. He died of fever, contracted when the war between Athens and Sparta was at its height. He was an able general and a famous orator, but did his beloved Athens irreparable injury by not foreseeing that personal government, nobly as it worked in his hands, must be ultimately ruinous to a nation.

Perkin, Sir William Henry

b. London, March 12, 1838.

Sent to the City of London School, the only institution of the character at the time where scientific subjects were taught, he became, at seventeen years of age, assistant to H. W. Hofman, the great chemist. When in his eighteenth year Perkin, at Hofman's instigation, was seeking to make artificial quinine, he obtained unexpected results. He had discovered the way to manufacture an aniline purple or mauve from coal-tar. The discovery was patented, and at eighteen years of age he was within sight of potential wealth inestimable. The process was worked by himself, his brother, and father, who soon made a vast fortune from it. From that laboratory experiment dates the gigantic industry in coal-tar products—dyes, scents, disinfectants, essences, and a thousand other things, which, developed mainly in German laboratories, have added hundreds of millions of pounds to the wealth of the world.

Peter the Great
b. Moscow, June 9, 1672. d. St. Petersburg, February 8, 1725.

At first he reigned jointly with his half-brother, the weak-minded Ivan, but at his death reigned alone. He Europeanised his army, and set about the creation of a navy and the provision of harbours, of which, at this time, Russia had but one—Archangel. He seized Azov, and then set forth to see what civilisation was doing for other peoples. He visited several countries, eventually reaching England. At Amsterdam, disguised as a labourer, he worked as a shipwright, and devoted his leisure to the study of science and philosophy. From England he carried back engineers artificers, surgeons, artillerymen, and artisans to the number of 500. At home he encouraged literature, developed trade with other countries, organised a national Church, and founded St. Petersburg. He was engaged in many wars and internal rebellions during his reign, but he extended his dominions, and made Russia a civilised nation. A genius in creative ability, he was a savage in his wrath, an Asiatic in his pleasures. Allowing for his limitations, he fully deserves his title "Great," for he was one of the most remarkable men of any age.

Peter the Hermit
b. Amiens, France, about 1050. d. Huy, Belgium, July 7, 1115

Though not a great man in the best sense of the term, Peter the Hermit was one of the most astonishing figures of his age. First a soldier in the service of the Counts of Boulogne, he abandoned wife and family and became a monk. Roused by stories of the sufferings of Christians in Palestine, he went throughout Europe preaching a crusade. Blessed by the Pope, Urban II., he traversed a great part of Europe, riding bareheaded and barefooted, carrying a cross. Everywhere his fiery eloquence caused him to be received as an inspired prophet. A great multitude followed him, clamouring to be led forthwith to the Holy Land. With Peter at their head, a mob of 40,000 enthusiasts set forth. They fought and slew and pillaged their way to Constantinople, and were practically exterminated by the Turks at Nicæa. The Crusade, led by Godfrey of Bouillon, was accompanied by Peter the Hermit, who, during the long siege of Antioch, was among those to lose heart and desert. He was carried back, to undergo a public reprimand. When at last Jerusalem was taken, the triumphant Crusaders fell at his feet and offered him thanks, as the original inspirer of their expedition. The life of Peter the Hermit is an amazing example of the power of one gifted enthusiast to inspire to lofty heroism practically the whole people of a continent.

Petrarch, Francesco de Parenzo
b. Arezzo, Italy, July 20, 1374. d. Arquà, Italy, July 18, 1374.

The same decree which banished Dante from Florence sent into exile the father of Petrarch, who settled at Arezzo, where the founder of the Classical Revival was born. From his earliest years Petrarch devoted himself to the study of literature, and in the days of his youth wrote the lovely lyrics which have maintained his fame undimmed for sixteen centuries. The death of his father left him without means, and he had to enter the Church. He never became a priest, but held various minor benefices, conferred by admirers of his genius. Of these there were many and powerful, and kings competed for the distinction of having him at their Courts. The "Laura" whom he immortalised he first met when he was twenty-three. She is supposed to have been the wife of Hugues de Sade, and to have been the mother of eleven children. Petrarch's passion for her was of the purest and loftiest order, as was that of Dante for his Beatrice. At thirty-five Petrarch was recognised as the first scholar and poet of his age, and was crowned laureate in Rome. His life for many years was passed at Courts and in the society of the most learned and cultured men in Europe. His literary output was prodigious, and —vain are our own judgments!—he deemed the work which he now did the work upon which his fame would rest. As a fact, it was forgotten or eclipsed in a later age, and is never read in our own. Petrarch lives for posterity in the exquisite poems of his youth.

Petrie, Sir William Matthew Flinders
b. Woolwich, June 3, 1853.

The grandson of Captain Flinders, the Australian explorer, he has made the buried past of Egypt the mission of his life. Tombs and temples have been made to tell the wonderful story of a civilisation and culture in the East, in comparison with which the ancient arts of Greece are modern. His discoveries have meant practically the re-writing of ancient history.

Petty, Sir William
b. Romsey, Hants, May 26, 1623. d. London, December 16, 1687.

He was the son of a small clothier, and, going to sea while a boy, was left, by sailors jealous of his attainments, with a broken leg upon the coast of France. Instead of striving to return home, he raised money by teaching English and navigation in France, and then entered himself at the Jesuit College at Caen, Normandy, where he received a good general education. Continuing his studies in Holland, he passed on to Paris, whither he was drawn by the fame of its scientists, and became associated with several notable men. Upon returning to England he was still very poor, but gained reputation by the invention of a copying machine and by sketching proposals for the formation of a scientific society. That society did eventually come into being on the lines which he had planned. It was the famous Royal Society, and he was one of its founders. With increasing reputation he was appointed a Fellow of Brasenose College, Professor of Anatomy and Music. Next he was appointed physician to the Army in Ireland, and surveyed the land forfeited to soldiers. He acquired considerable possessions, and founded important industries. His daughter married Thomas Fitzmaurice, Earl of Kerry, and from this marriage descend the Marquises of Lansdowne.

Phidias
b. Athens, about 490 B.C. d. Athens about 432 B.C.

The greatest sculptor of antiquity had the good fortune to live when Pericles was bedecking Athens with beauty, and to receive commissions to execute the chief statues and to supervise all the similar work of the capital. He constructed the Propylæa and the Parthenon, and adorned them with stupendous figures, acclaimed by antiquity as the most impressive and beautiful ever produced by man. The glorious Elgin marbles, fragmentary remains of the Parthenon frieze, remain as some evidence of his masterly work. The enemies of Pericles, afraid openly to attack him, assailed him through his nearest friends, of whom Phidias was one. They charged him with appropriating gold intended for his wonderful statue of Zeus. He was able to prove his innocence of this, so they charged him with impiety, he having introduced a portrait of himself into the statue of the goddess. He is supposed to have died while in prison on this second charge.

Pindar
b. near Thebes, Greece, about 522 B.C. d. Argos, Greece, 443 B.C.

The most famous and popular lyric poet of his day, he is the only Greek poet of whose work any considerable portions remain to us. Those preserved are the four books of odes celebrating the victories won in the Olympian, Pythian, Nemean, and Isthmian games. They present a striking picture of the importance which the athletic contests of the age occupied in the minds of the cultured Greeks. Pindar wrote also hymns to the

gods, pæans, lamentations for the dead, as well as odes to the victors in the games. Only the last survive entire. Pindar was a member of a talented family, members of which were renowned as masters of the flute.

Pitt, William

b. near Bromley, Kent, May 28, 1759. d. Putney, January 23, 1806.

The second son of the Earl of Chatham, who trained him from his earliest years to politics, the younger Pitt took naturally to statesmanship, and when he became Chancellor of the Exchequer at twenty-three, and Prime Minister at twenty-four, he entered upon his tremendous responsibilities with as much confidence as if he had been twice his age. For twenty years his power was unbroken, and he established for himself a position as one of the greatest statesmen in history. He enhanced the powers of the House of Commons as the representatives of the nation; he abolished sinecure offices, and stamped out corruption; he reformed the revenue methods of the country, and re-established its finances. For long he managed to keep peace with the Continent, but the French Revolution at last drove him to war. His greatest triumph was Nelson's Trafalgar victory. Pitt was now designated the "Saviour of Europe." His reply has become a classic: "Europe is not to be saved by any one man. England has saved herself by her exertions, and will, as I trust, save Europe by her exertions." A month later came news of Napoleon's wonderful victory at Austerlitz, and this proved Pitt's death-blow. He died less than two months later. Pitt was a great orator, a great financier—except when his personal interests were engaged—a born leader of men, but he had his weaknesses. He conferred titles with cynical indifference to the claims of the recipients; he permitted scandalous corruption in the deal by which the union of England and Ireland was effected; he abandoned Parliamentary reform and the abolition of the slave-trade when opposition came from Parliament, and cast aside Catholic emancipation when the King objected. In private life he was blameworthy for his hard drinking—a weakness of his era—and for the hopeless incompetence with which he permitted his affairs to drift into confusion. Otherwise, his character was singularly amiable and exemplary, and on his death-bed he found consolation in reflecting on "the innocence of his life."

Plato

b. Ægina, about 427 B.C. d. Athens, 347 B.C.

A disciple of Socrates, and the teacher of Aristotle, his teaching, with that of his master and pupil, has largely controlled the progress of speculative thought to the present day. In his youth he was a gymnast, a soldier, and a poet. He burned his poems upon coming under the influence of Socrates. After the death of the latter he travelled, and was seized and sold as a slave in Ægina, but was ransomed. Returning now to Athens, he started his Academic School. The academy was a grove. There, and in his own garden, he would walk and talk with his disciples, teaching them mainly by conversation, and embodying the results of his thinking in his written "Dialogues." He enjoyed a peaceful and prosperous old age, and died at a wedding feast. All the best of his philosophical writings have been preserved, together with many whose authorship is not clearly traceable to him. Plato is the greatest master of Greek prose style that ever lived, and is accounted as unapproached among mankind for the magnificent sweep of clear intellect, and the beauty and gorgeousness of poetic expression of his expositions.

Playfair, Lyon, Lord

b. Meerut, India, May 21, 1819. d. London, May 30, 1898.

He began his scientific career under the noted chemists, Graham and Liebig, and turned his knowledge to account in the practical application of science to commerce and the everyday affairs of life. He managed an important bleaching works, and was the one to suggest ways and means of developing a little stream of oil in Derbyshire which was to prove the parent of the paraffin and petroleum industries of the world. He was King Edward's master in practical chemistry; he served on many commissions dealing with the health and commodities of the nation; he performed inestimable service for the cause of education. For many years he sat in Parliament, and acted as Deputy Speaker. His last letter was to Mrs. Gladstone, sympathising with her upon the death of her husband, whose decease preceded his own by only nine days.

Plutarch

b. Chæronea, Greece, about 46 A.D. d. Greece, about 120 A.D.

The encyclopædist of antiquity was educated at Athens, but visited Rome, and lectured there on philosophy. The greater part of his days, however, were spent at Chæronea, his native place. There he wrote his discourses and his immortal "Lives." With the latter every student is familiar. They are biographies of warriors, statesmen, legislators, and heroes of ages preceding his own. They are precious documents, based on records which have long been lost.

Poe, Edgar Allan

b. Boston, Mass., January 19, 1809. d. Baltimore, October 7, 1849.

This gloomy genius was left an orphan when three years of age, but was adopted by a wealthy and kind-hearted man whose generosity he ill requited. Educated in London and at the University of Virginia, he got into disgrace at the latter through dissipation and gambling, and was removed to his patron's counting-house. He absconded and enlisted, was bought out, and sent to a military academy, from which he was dismissed for neglect of duty. Thrown on his own resources, he wrote poems and criticisms and stories for newspapers and magazines, one of which he edited. His most famous story, "The Gold Bug," was written to win a £20 competition; his greatest poem, "The Raven," was written for a New York evening paper. He gave way periodically to gross intemperance, and was frequently in direst poverty. His wife died when his affairs were in a hopeless condition, and he attempted suicide. Recovering, he was about to marry a second time, when he had another outburst, and was picked up in a public street, sodden with drink and dying. He was a genius of a peculiar order, with all the infirmities of genius, and few of its redeeming qualities.

Polo, Marco

b. Venice, 1254. d. Venice, 1324.

One of the earliest and greatest of travellers, Marco Polo was only a boy when he set out with his father and uncle to China. The elder Polos had already wandered thither, had been handsomely received by Kublai Khan, the Emperor, and by him commissioned to lead a hundred learned men from Europe to the Celestial Empire. When they set out two friars accompanied them, but soon turned back, and the three Polos went on alone, by Sivus, Mosul, Bagdad, and Ormuz, through Khorasan, up the Oxus to the Pamir plateau, through Kashgar, Yarkand, along Lake Lob, over the Great Gobi Desert, and so to Shangtu, near the modern Peking, where Kublai Khan was staying. For seventeen years they were honoured guests at the Imperial Court. Marco was made an ambassador, and visited Cochin-China, India, and elsewhere. Finally, the three returned, wealthy, to their native land, coming back by way of Sumatra, the Straits of Malacca, Ceylon, and Ormuz. During a battle between the Venetians and Genoese, Marco was taken prisoner and cast into gaol. His misfortune

was a blessing to posterity, for he recounted his adventures to a fellow prisoner, who gave them to the world in the form of a book. That book did much to stimulate the love of travel, and was of great assistance to Columbus and other seekers after a sea-way to India.

Pope, Alexander

b. London, May 21, 1688. d. Twickenham, May 30, 1744.

His father, a linendraper, having become a convert to Roman Catholicism, Pope had no regular training in the public schools, but laboured with prodigious zeal privately to equip himself. His intense application to study while still a child ruined his health, and his sickly constitution undoubtedly gave that jaundiced bias to his mind by which he was throughout life affected. At twelve he had already begun to write poetry, and at fourteen produced his "Ode on Solitude," a surprising work for one so young. While he was still in his 'teens he was introduced by Wycherley into the society of the literary lions of the age—Addison, Steele, Swift, and Arbuthnot. "The Rape of the Lock," one of his finest productions, was published in his twenty-fourth year, and "Windsor Forest" in the year following. His translation of Homer began when he was twenty-four. The "Iliad" occupied him seven years, and brought him fame and fortune. The "Odyssey" occupied a further five years, and was not so successful, owing to his having entrusted parts of the work to hands less skilled than his own. "The Dunciad" was written while the "Odyssey" was in progress, but it was not published until 1728, so that between its completion and issue Pope might have time deliberately to sting into fury the victims of his lampoon, then represent their anger as having induced him to write it. This was characteristic of Pope, who was always planning and plotting to deceive posterity into a belief in and admiration for a spontaneity which he did not possess. The "Essay on Man," produced when he was forty-five, like two of his earlier works, abounds in lines and couplets which have passed into the habitual conversation of our lives. Pope was one of the most extraordinary geniuses produced by England. Soured by bodily infirmity, by perpetual animosities, and by ungratified vanity, he could stoop to the meanest, most stupid deceits, yet he was tender-hearted and loyal to the weak and suffering. He had inspiration, yet never passed a line or phrase until it had been refined and burnished into perfection. He laboured at his work with all his energy, yet desired the world to believe that it was dashed off in bursts of enthusiasm and sent in hot haste to the printers. The life story of the man does not inspire admiration; he is best studied in his works.

Preece, Sir William Henry

b. Carnarvon, February 15, 1834.

Though he inclined more to music than to science, it was in electricity and its many applications to practical affairs that he was destined to distinguish himself. He played an important part in the development of the telegraph in Britain and in the Colonies, and, as Consulting Engineer to the Post Office, was responsible for innumerable inventions of importance. He invented a system of wireless telegraphy ten years before that of Marconi was announced; he adapted electricity in many ingenious ways to the purposes of railway work—not only as to signals, but as a motive power—and has edited quite a library of the literature of the science to which he has devoted his days. He introduced the telephone and the phonograph into Britain, and gave us the first of wireless telephones.

Prescott, William Hickling

b. Salem, Mass., May 4, 1796. d. Boston, January 28, 1859.

While he was studying at Harvard he was deprived, through an accident, of the sight of one of his eyes, but the calamity did not keep him from unremitting study to qualify himself for the task of the historian. He employed a reader, and devised a special apparatus to assist him in his work, and, though practically blind, he produced works of lasting fame on Spanish history, on Mexico, and on Peru. He was still toiling at his history of the reign of Philip II. when overtaken by death.

Priestley, Joseph

b. Leeds, March 13, 1733. d. Northumberland, Pa., February 6, 1804.

The son of a cloth-dresser, he was successively Dissenting minister, school teacher, and librarian. In the latter capacity he served Lord Shelburne, whom he accompanied on a journey to the Continent. There he met Lavoisier and other great chemists, and communicated to them his discovery of oxygen. In their hands this discovery revolutionised chemistry. Disciples of Lavoisier claim for their master that he discovered oxygen and the composition of water independently of Priestley, but the Englishman's title to credit seems clear, though Lavoisier gave oxygen its name. Priestley had called it "dephlogisted air," believing the gas to be air deprived of the so-called phlogiston, in which he believed to the end. He made many other important discoveries, but left to others their correct interpretation. Cavendish laid the foundation of pneumatic chemistry, but Priestley so improved upon his apparatus as to be called the father of pneumatic chemistry. His religious views were generally regarded as heterodox, and towards the close of his career he emigrated to America, there to await the second coming of Christ.

Prior, Matthew

b. East Dorset, July 21, 1664. d. Wimpole, Cambs, September, 18, 1721.

Left fatherless at an early age, he became bookkeeper to his uncle, a vintner, but was befriended by the Earl of Dorset, and enabled to study at Cambridge. Although he is best remembered by his literary productions, in which occur lyrics and epigrams of surpassing excellence, he filled many diplomatic and State offices, and succeeded Locke as Commissioner of Trade and Plantations. His politics brought him to grief, the ascendancy of his enemies leading to his impeachment and incarceration (1715-1717) in gaol.

Ptolemy

b. Alexandria, 2nd century, A.D. d. Alexandria, about 160 A.D.

Although Claudius Ptolemæus borrowed more from the works of Hipparchus than he acknowledged, he was the author of much important independent discovery in astronomy and optics. With the scanty data at his disposal he came to the conclusion that the earth is the centre of the universe, with the heavenly bodies revolving around it. His theories held good until the system of Copernicus upset them. As a geographer he filled an important place. His calculations were often erroneous, but, considering the meagre character of his information, they were remarkably good guesses. One respect in which he was at fault was in his estimate of the circumference of the globe. Columbus, basing his calculations on Ptolemy's works, supposed the distance from the western coast of America to the eastern coast of Asia to be one-third less than is actually the case, and in that belief was encouraged to attempt the voyage which led him to the discovery of America.

Purcell, Henry

b. London, 1658. d. Westminster, Nov. 21, 1695.

Admitted as a chorister of the Chapel Royal, he composed an ode, when only twelve years of age, on the King's birthday; and he was but seventeen when he gave to the world his notable opera, "Dido and Æneas." He wrote much fine church and chamber concert music, as well as composition for less formal use, and in every respect surpassed all predecessors in this country. His music is still popular, more than two centuries after his death.

Purchas, Samuel
b. Thaxted, Essex, 1577. d. London, September, 1626.

A clergyman, he compiled books of travel which possess the highest historical value. During the latter part of his career he was Rector of St. Martin's, Ludgate Hill.

Puschkin, Alexander Sergejevich
b. Moscow, May 26, 1799. d. St. Petersburg, January 29, 1837.

Puschkin was one of the greatest of Russian poets, the son of a woman of negro descent. Although his political views were far in advance of his age in Russia, he was repeatedly employed in the administrative work of the Government, but after a semi-exile he was dismissed and confined to his estate. He died of wounds sustained in a duel.

Pythagoras
b. Samos, Greece, about 580 B.C. d. Crotona, about 500 B.C.

He was a famous philosopher, and founder of the school of philosophy called after his name. He left no writings, our knowledge of his teachings and institutions depending on the traditions of his disciples.

Quincey, Thomas de
b. Manchester, August 15, 1785. d. Edinburgh, December 8, 1859.

This brilliant essayist and miscellaneous writer was the son of a wealthy linendraper, but, owing to his erratic conduct as a youth, had to undergo severe privations in London before going to Oxford University. Here he contracted the opium habit, and upon his weakness based his famous "Confessions of an English Opium-eater," which at once established his reputation. His many charming writings were contributed, for the most part, to magazines, and not published in book form until shortly before his death. He long shared the friendship in the Lakes of Coleridge and Wordsworth.

Racine, Jean Baptiste
b. La Ferté-Milon, France, December 21, 1639. d. Paris, April 21, 1699.

The greatest of French tragic poets was left an orphan at an early age, but was carefully educated by his grandparents, and received into the best literary society of his age. His literary career began with the publication of odes, but his friendship with men like La Fontaine, Boileau, and Molière led him to devote himself to the drama. In this he achieved striking successes, until either successful rivalry or his conversion to religion turned him finally to poetry. As a poet he was even greater than as a dramatist, and bequeathed to posterity some of the most exquisite melody in words ever conceived by the mind of man.

Raikes, Robert
b. Gloucester, September 14, 1735. d. Gloucester, April 5, 1811.

Moved by compassion for the desperate lot of the children of the poor, he started a Sunday-school in Gloucester, at which they were taught to read and write and instructed in the Christian faith. The first of its kind ever established, it was a success from the outset, and became the parent of the entire Sunday-school movement. Raikes was a newspaper owner.

Raleigh, Sir Walter
b. near Sidmouth, Devon, 1552. d. London, October 29, 1618.

One of the towering figures of Elizabethan days, Raleigh had all the daring and imagination of the hero of romance. He was a brilliant and daring soldier, a dauntless explorer, a polished statesman and courtier, a distinguished scientist and author. After completing his education at Oxford, he served five years abroad as a volunteer in aid of the Huguenots, then took part in the expedition to America. He gained the favour of Elizabeth, who heaped riches and honours upon him. His attempt to colonise that portion of America to which she gave the name of Virginia cost Raleigh £40,000, and yielded to England at the outset tobacco and the potato. Raleigh was ever the foe of Spain, and had a brave part in the destruction of the Armada, and in many lesser engagements with the great Catholic nation in the Old World and the New. Threatened in the affections of Elizabeth by the handsome and gallant Essex, Raleigh repaired to Ireland, where the Queen had given him an estate of 40,000 acres. He was soon restored to favour by the Queen, who would have made Raleigh's career more glorious had she not so dotingly kept him at Court when he was planning greater enterprises. However, his favour ended when his intrigue with Bessy Throckmorton was discovered. Tales of the riches of Guiana drew Raleigh from retirement, and he set sail on an expedition of discovery, and published an account of his doings. With the accession of James I. Raleigh was accused of treason, and condemned to death. For long he was kept a prisoner, then was released, to go again to Guiana. His expedition failed, and upon his return he was re-arrested and executed.

Ramsay, Sir William
b. Glasgow, October 2, 1852.

One of the most distinguished of modern scientists, he was educated at Glasgow, and Tübingen Universities, and, after a successful career as tutor and college principal, won renown by researches into the constituents of air. In conjunction with Lord Rayleigh, he discovered argon. Besides the discovery of helium, he has identified and measured the previously unknown elements in the air, which he has named neon, krypton, and xenon. Awarded the Nobel prize in chemistry in 1904, he has been honoured by practically all the most famous learned and scientific bodies of Europe.

Ranke, Leopold von
b. Wiehe, Germany, December 21, 1795. d. Berlin, May 23, 1886.

Educated at Leipsic, he held professional appointments at Berlin, became historiographer of Prussia, and wrote many notable volumes on history. His works are distinguished by their statesmanlike breadth of view, but they rather neglect the social side of national development.

Raphael (or Raffaello Sanzio)
b. Urbino, Italy, March 28, 1483. d. Rome, April 6, 1520.

The prince of painters was the son of a poet and painter, and from an early age began the study of art, under his father and Vito; then, after the death of the former, under Perugino. The latter he excelled, and, going to Florence at twenty-one, was ripe for the influence of Michael Angelo and Leonardo da Vinci. For four years he lived in this atmosphere of supreme art, and executed some of the noblest of his works. Invited to Rome by Pope Julius II., he spent there the last twelve years of his life, and in that time produced an amazing number of works. It was as if he foresaw that his years were to be few—he died at thirty-seven—and that he must labour with all haste. Hard as he worked, he never permitted any of his pictures to suffer from lack of due care. He erred, indeed, in the opposite direction, seeking to combine too many perfections, and falling short of his own best. He left an enormous number of paintings, portraits, studies, drawings, sketches, and studies. Besides this, he was a sculptor of high ability, and acted as master architect of St. Peter's at Rome, in addition to superintending the excavation of antiquities. A man of many friendships, to the end he was unspoiled by his success, and was said to be beloved not only by all men, but by the very brutes.

Ray, John
b. near Braintree, Essex, November 29, 1627. d. near Braintree, January 17, 1705.

The son of a blacksmith, he became a *Fellow* of Trinity College, and devoted himself to natural history. His classification of plants was the foundation of the "natural system"; his zoological works were the basis of all modern zoology.

Rayleigh, John William Strutt, Lord
b. Witham, Essex, November 12, 1842.

At Cambridge he was the Senior Wrangler and Smith's Prizeman, and became, at thirty-seven, Professor of Experimental Physics there, and afterwards succeeded Tyndale as Professor of Natural Philosophy at the Royal Institution. His most popular work was the discovery, with Sir William Ramsay, of argon; but his labours in the whole field of science have been of the greatest importance in many directions. He has not hesitated to go again over ground broken by others, and the result has been that either he has said the final word upon the subjects, or opened up entirely new horizons of discovery.

Rembrandt, Hermanszoon van Rhyn
b. Leyden, Holland, July 15, 1607. d. Amsterdam, October 8, 1669.

His father was a prosperous miller, and he was afforded a good education, though his art was mainly self-developed. He showed much independence of convention and example, and went to Nature for his inspiration. His works became famous until disaster overtook him. His wife, who had brought him a fortune, died; then he became bankrupt, and saw all his treasures sold. His closing years were passed in poverty and wretchedness. He toiled incessantly, but his art had declined in popularity, and the creator of some of the noblest works in existence had to be buried at the public expense.

Rennie, John
b. East Lothian, June 7, 1761 d. London, October 4, 1821.

He began life as a millwright, but by great diligence became one of the foremost engineers of the age. The Southwark, Waterloo, and London bridges were built from his plans while he designed the London Docks, the India Docks, and others in the provinces, as well as the dockyards at Portsmouth, Chatham, Sheerness, and Plymouth.

Reynolds, Sir Joshua
b. near Plymouth, July 16, 1723. d. London, February 23, 1792.

Educated by his father, a schoolmaster and clergyman, he afterwards studied painting in London and at Rome. Then he caught a chill, which rendered him deaf. Returning to London, he rapidly established a high reputation as a painter, and upon the formation of the Royal Academy became its first president. In the following year he began his famous "Discourses" to the students. Three years before his death his sight failed, and he was compelled to relinquish painting. His portraits placed him at the head of the English school of portrait-painting, in which he has never been surpassed. He enjoyed the friendship of the literary lions of his time, and founded the Literary Club, which had among its members Johnson, Garrick, Burke, Goldsmith, Boswell, and Sheridan.

Rhodes, Cecil John
b. Bishop-Stortford, July 5, 1853. d. near Cape Town, March 26, 1902.

A son of the rectory, he went as an invalid in search of health to Natal, and remained, to make a fortune from the Kimberley diamond-mines. But, while he was making himself one of the richest men in the world, he was dreaming dreams of empire—of a stretch of country, "all British," from the Cape to the Zambesi. He returned to England, and took his B.A. and M.A. at Oxford University, and was for a time a law student. While South Africa was developing, he financed many undertakings which were making for progress, entered the Cape Parliament, and was hopeful enough of the future to decline the invitation of his friend, General Gordon, to accompany him to Khartoum. Foiled by the Cape Parliament in the attempt to take over a large part of Bechuanaland, he was more successful with the Imperial Government, by which he was appointed Deputy Commissioner for the new Protectorate. Events marched quickly now. He consolidated the various diamond-mining companies at Kimberley, became Premier of the Cape Parliament, and secured a charter for the British South Africa Company, whose territory is now known as Rhodesia. The Jameson Raid into the Transvaal, in 1896, checked his political career, but not his imperial projects. To the end he was actively engaged in furthering his scheme for making homes in South Africa for the British colonists. He died of heart disease, the complaint from which all his life he had suffered. His will is a notable document. It includes bequests to Oxford University, and provides scholarships for English-speaking students from various parts of the world.

Richardson, Samuel
b. Derbyshire, 1689. d. London, July 4, 1761.

The father of the English domestic novel was the son of a carpenter and joiner, and was apprenticed to a London printer. His proficiency with his pen in an age when penmanship was a rare art among the lower classes led to his frequent employment by young people desiring to correspond with their sweethearts and relatives. This practice gave him an insight into the ways and needs of humble life, and led to his publishing his first book—a volume for the instruction in letter-writing of the illiterate. The same didactic scheme prompted the writing of his novel "Pamela," which he designed "to cultivate the principles of religion and virtue in both sexes." The book had a remarkable vogue, and encouraged him to patient effort in the production of his masterpiece, "Clarissa Harlowe," which Johnson declared to be the first book in the world for its knowledge of the human heart.

Richelieu, Armand Jean Duplessis, Cardinal, Duc de
b. Poitou, France, September 5, 1585. d. Paris, December 4, 1642.

Born a son of the Grand Provost of France, he aspired to a military career, but upon his brother throwing up his bishopric to become a Carthusian, the younger Richelieu had to succeed him, and so did, when twenty-two. In 1614 the States General, which was not again to be convoked until 1789, assembled, with Richelieu as a deputy from Poitou. His support of the queen-mother, Mary de Medici, led to her appointing him as her grand almoner, and his political career had begun. He rose to the position of Secretary of State, but fell when she retired to Blois, and accompanied her thither. He succeeded in reconciling the queen and her son, Louis XIII., and was appointed Minister by the latter. Thenceforth Richelieu was virtually King of France. He crushed the plotting nobles, who were battening like birds of prey upon the country; he destroyed the political power of the Huguenots, struck heavy blows at Spain and Austria, and vastly extended French influence. A prince of schemers himself, he was constantly plotted against, and was seldom free from danger. Personal ambition had no part in his procedure. He sought to enhance the prestige of his country by strengthening the Crown. All constitutional government and all vestiges of local liberty were destroyed. He was merciless and implacable, but it was against the most powerful foes of his country that his blows were chiefly aimed. He prepared the way for the Revolution.

Richter, Jean Paul Friedrich
b. Wunsiedel, Bavaria, March 21, 1763. d. Bayreuth, November 14, 1825.

A famous humorist, and one of the most gifted of German writers, he had a long and hard struggle with fortune before winning recognition. His first writings were a failure, and he had to earn his bread by teaching while writing works which were to make him one of the most famous men of his era. Success having once come to him, it stayed, and he was almost idolised by his generation.

Ridley, Nicholas
b. Haltwhistle, Northumberland, about 1500. d. Oxford, Oct. 16, 1555.

After studying at Cambridge and on the Continent, he became domestic chaplain to Cranmer and Henry VIII., Bishop of Rochester, and finally Bishop of London. An ardent advocate of the Reformation, he was arrested under Mary, and after a long imprisonment was, with Latimer, burned as an obstinate heretic.

Rodin, Auguste
b. Paris, Nov., 1840.

Although receiving an artistic training, he had in early manhood to engage in menial labour for a livelihood, but became famous at once with the bust called "The Broken Nose," which was exhibited when the sculptor was only twenty-three. Like other great artists, he has not always had the critics on his side, but later years have brought him indisputably to the head of his profession.

Rodney, George Brydges, Lord
b. Walton-on-Thames, Feb. 19, 1719. d. London, May 24, 1792.

He served in the Seven Years War, gained a great victory over the Spaniards at Cape St. Vincent, captured Martinique, St. Lucia, and Grenada, and, by defeating the French at Havre, destroyed the flotilla by which it had been intended to invade England.

Romilly, Sir Samuel
b. London, March 1, 1757. d. London, Nov. 2, 1818.

The son of a watchmaker, he became a great lawyer, and attained to the position of Solicitor-General. He is famous for his untiring efforts to reform the criminal law of England, which, in his day, was a barbarous code, including capital punishment for comparatively trivial offences. When sixty-one he lost his wife, and was so distressed at her death that he took his own life.

Romney, George
b. Dalton, Lancs, Dec. 15 1734. d. Kendal, Nov. 15, 1802.

He joined his father in the workshop as a cabinet-maker, but showed unmistakable evidence of genius as an artist, and eventually became one of the most distinguished of English portrait-painters. The most famous of his works are his portraits of Lady Hamilton. His paintings have increased in value to thirty or more times the prices which he obtained.

Ronalds, Sir Francis
b. London, Feb. 1788. d. Battle, Aug. 8, 1873.

A London merchant's son, he early interested himself in mechanics and electricity, invented an electric telegraph, and established it, with eight miles of insulated wire, in his garden at Hammersmith. He offered to demonstrate his invention before the Admiralty, but was answered: "Telegraphs of any kind are now totally unnecessary, and no other than the one now in use will be adopted." The one then in use was the old semaphore. He bore his rebuff with much good-humour, bade "a cordial adieu" to electricity, and set himself to the invention of an instrument which has proved invaluable to meteorologists and physicists. Wheatstone and Cook afterwards developed the Ronalds telegraph, and had it publicly used twenty-one years after he had offered it to the Admiralty.

Rontgen, William Konrad von
b. Lennep, Germany. March 27, 1845.

He was trained in Holland and at Zürich, and began to teach at Würzburg and Strasburg. At the former place, while experimenting with a highly-exhausted vacuum tube on the conduction of electricity through gases, he discovered the famous X-rays, now called, in his honour, Röntgen rays. He has distinguished himself in other branches of science, but it is by this discovery that he is popularly known to the world.

Rosa, Salvator
b. nr. Naples, June 20, 1615. d. Rome, March 15, 1673.

Intended for the Church, he devoted himself to musical composition, but by frequenting the studio of his brother-in-law became imbued with a love of art, and adopted painting as a profession. After working for some time in obscurity, he attained fame with his picture, "Tityrus tortured by the Vulture"; and, removing to Rome, raised himself to independence and celebrity. He was gifted as poet and satirist, as well as musician and painter, and his writings are still read. In art he was distinguished by the gloomy grandeur and terrible magnificence of his pictures.

Salt, Sir Titus
b. Morley, Yorks, Sep. 20, 1803. d. Saltaire, Yorks, Dec. 29, 1876.

The son of a cloth manufacturer who turned farmer. Salt was brought up to the trade of a wool-stapler, and invented a process for turning to profit alpaca, a fabric which had previously defied all efforts to render it saleable. Salt accomplished with alpaca as great wonders as Lord Masham achieved with silk-waste, and founded the model manufacturing town of Saltaire for his works and workpeople.

Sand, George
b. Paris, July 2, 1804. d. Nohant, France, June 7, 1876.

"George Sand" was the assumed name of Amantine Lucile Aurore Dupin, Baroness Dudevant, novelist, playwright, and miscellaneous writer. Married at eighteen, she quitted her husband for the Bohemian literary life of Paris, where among her intimates were Jules Sandeau, Alfred de Musset, and Chopin.

Sappho
b. Mytilene (?), Asia Minor, 7th Century, B.C.

Just as "The Poet" served as sufficient description of Homer, so "The Poetess" was the description of Sappho, one of the greatest of Greek lyrists. Only two of her odes, and about 150 scattered, broken lines remain, but by ancient writers and modern she is proclaimed the only poet whose every word has a seal of absolute perfection and inimitable grace.

Sargent, John Singer
b. Florence, 1856.

The son of an American physician, he grew up in an artistic atmosphere, and, trained by Carolus Duran, has developed into one of the foremost portrait and genre painters of the age.

Saunderson, Nicholas
b. Thurlston, Yorks, Jan., 1682. d. Boxworth, Cambs. April 19, 1739.

Although blind from infancy, he became an accomplished scholar and famous as a lecturer at Cambridge University, whither he was taken as a poor student by a sympathetic friend.

Savonarola, Girolamo
b. Ferrara, Italy, Sep. 21, 1452. d. Florence, May 23, 1498.

First a Dominican monk and later prior of St. Mark's, Florence, he had enormous influence by his fearless denunciation of the vice and corruption in Church and State. He brought about a great religious revival and led to the overthrow of the Medici, but the lasting animosity of Pope Alexander VI., whom he had assailed, brought his arrest and barbarous execution.

Schule, Karl Wilhelm
b. Stralsund, Dec. 2, 1742. d. Koping, Sweden, May, 1786.

While serving as a chemist's apprentice, and afterwards as a pharmist, he made an unparalleled series of discoveries, in the course of which, independently of Priestley, he discovered oxygen and nitrogen. Among his many other discoveries were: Oxalic, tartaric, citric, lactic, and arsenic acids and their salts; baryta and the salts of barium; uric acid and the composition of prussic acid and Prussian blue.

Schiller, Johann, Christoph Friedrich von

b. Marbach, Germany, Nov. 10, 1759. d. Weimar, May 9, 1805.

The son of an army surgeon, he first tried the law, but turned to medicine, and entered the army as a surgeon. But the pen early claimed his affections, and at twenty-three he was in disgrace for a play of revolutionary tone. He fled from Stuttgart, and though afterwards his successes as dramatist and poet were second to those of no other man of his age, he and poverty were never for long strangers. Philosophy and poetry are admirably blended in his works. With Goethe he succeeded in elevating the German drama and in moulding and purifying the thought and language of a great people.

Schubert, Franz Peter

b. Vienna, Jan. 31, 1797. d. Vienna, Nov. 19, 1828.

The son of a musician, he early showed a genius for composition, but the times were not propitious, and the privations which he suffered during youth brought him to an early grave. He composed 500 songs, among which are some of the loveliest in existence, ten symphonies, six masses, several operas, cantatas and overtures, and a host of sonatas and other compositions.

Schumann, Robert

b. Zwickau, Saxony, June 8, 1810. d. near Bonn, Germany, July 29, 1856.

He did not take up the study of music until twenty-one years of age, but two years later he published his first important composition, and in the following year began his writings on music. His subsequent career was chequered. Beautiful compositions were followed by spells of madness, and he died in an asylum for the insane. His music is distinguished by freshness and originality, much piquancy in rhythm and wealth and resource in harmony.

Scipio, Publius Cornelius Africanus Major

b. 237 B.C. d. Campania, Italy, 183 B.C.

A soldier from his youth up, he gained great successes for the Roman arms, and caused the recall of Hannibal from his invasion of Italy to defend Carthage. Scipio inflicted upon him his only defeat, and ended the second Punic War.

Scott, Sir Walter

b. Edinburgh, Aug. 15, 1771. d. Abbotsford, Sep. 21, 1832.

An early illness, though it left him lame for life, was a blessing in disguise, for he was given the run of an ample library, there to store his mind with reading which no ordinary boy would have attempted. Brought up to the law, as his father had been, he first became known by translations of German writings, following this with poems of his own. His original poems speedily brought him fame, and fearing that he might sacrifice this if he appeared as a novelist, he published the early volumes of the immortal "Waverley" novels anonymously, and stoutly denied the authorship when challenged. Not until twenty-five of them had appeared did he publicly admit their parentage. A secret partnership with the Ballantynes proved an inauspicious venture, and upon Constable taking over the business and failing, Scott became involved in a loss of £120,000, in addition to £30,000 private debt. His declining years were devoted to paying off this sum, and in the end, after his death, every creditor had his due. Not only did Scott write poems and novels and a vast number of miscellaneous articles; he edited large editions of Dryden and Swift, and wrote a nine-volume "Life of Napoleon." His baronetcy was conferred by George IV., of whom the Jacobite genius was, paradoxically enough, an ardent admirer.

Selden, John

b. Salvington, Sussex, Dec. 16, 1584. d. London, Nov. 30, 1654.

A poor boy, bred to the law, he became a successful lawyer, but found time for wide and profound study, and for the production of deeply learned historical, antiquarian, and legal works. His resolute stand for liberty caused him to be imprisoned for nearly a year in the Tower, without, however, abating his zeal for the right. He helped to draw up the Petition of Right, but did not take part in the impeachment of Strafford or in Laud's prosecution, while he was opposed to the execution of Charles I.

Shaftesbury, Anthony Ashley Cooper, 7th Earl of

b. London, April 28, 1801. d. Folkestone, Oct. 1, 1885.

While still a schoolboy he determined to devote his life to ameliorating the condition of the poor. He helped to reform the law in its relation to the treatment of lunatics, for the prevention of the employment of boys as chimney-sweeps, and for the Factory and Workshop Regulation Acts. He was a devoted friend of the Ragged School movement, and was a foremost figure in all the social reforms effected during his lifetime.

Shakespeare, William

b. Stratford on Avon, Ap. 23 (?), 1564. d. Stratford on Avon, Ap. 23, 1616.

The greatest of dramatists and one of the most gifted of poets had for his father a fellmonger and glover, while his mother was a woman of some fortune. Comparatively little is known of his life. A reverse in the fortunes of his father compelled him to take service, with but scanty store of education, as apprentice to a butcher, while there is a tradition as to his being employed in the office of an attorney. Married, while a youth, to Anne Hathaway, he was the father of a daughter at nineteen, and a few years later quitted his native town, impelled, it is supposed, by a prosecution for deer-stealing. His early life in London is obscure, but it is supposed that at the outset he earned a livelihood by holding horses near the spot where he was to gain more or less renown as an actor in his own plays. The first of these, preceded by the poems "Venus and Adonis" and "Lucrece," was probably "Love's Labour's Lost," followed by the "Comedy of Errors," "Two Gentlemen of Verona," and "A Midsummer Night's Dream." Play followed play with amazing rapidity, the author's genius developing in new directions with each production. "The Merry Wives of Windsor" is said to have been hastily produced in compliance with Queen Elizabeth's command that he should exhibit Falstaff in love. Shakespeare was by this time a prosperous man. He wrote for the hour, not for posterity.

"For gain, not glory, wing'd his roving flight,
And grew immortal in his own despite."

His raw material for comedy and historical drama and tragedy he took from various sources—old plays, old chronicles, the writers of antiquity. "The Winter's Tale" dramatises a novel. He bought a residence at Stratford and another in London, and died at the former in his forty-ninth year. Seven years elapsed between his death and the appearance of the first collected edition of his works, and scholars to this day are not able to say quite where his pen ceased and others began. The mystery is little less perplexing than that by which the works of Homer are invested. But those works, wholly his, or touched here and there by the hand of a collaborator, remain the chief literary heritage of the Anglo-Saxon race, even if Landor spake not truly when he said "Shakespeare is not our poet, but the world's!"

Shelley, Percy Bysshe
b. near Horsham, Sussex, Aug. 4, 1792. d. Spezzia Bay, Italy, July 8, 1822.

Expelled from Oxford University for an atheistical pamphlet, Shelley, out of chivalrous desire to save from suicide the daughter of a coffeehouse-keeper, married her. He was nineteen, she was seventeen. They parted three years afterwards, and he went to Switzerland with Mary, daughter of William Godwin, whom, upon the suicide of his wife, he married. The second union was productive of much happiness for the poet, whose finest work was now produced. He was drowned while sailing in the Bay of Spezzia, and his body, recovered eleven days later, was burned upon the shore in the presence of his friends Trelawny, Leigh Hunt, and Byron.

Sidney, Sir Philip
b. Penshurst, Kent, Nov. 29, 1554. d. Zutphen, Holland, Oct. 17, 1586.

Warrior, statesman, poet, he experienced the full force of a capricious queen's power to wound a subject, and met his death in an expedition against the Netherlands, undertaken for policy's sake at Elizabeth's behest. His literary masterpieces were unknown to the world at large during his lifetime, for, though celebrated in Court circles, they were not published until after his death. His writings have proved a well of inspiration at which many later poets have drunk deep; his career was a pattern to all who strive to live the life of a true gentleman.

Siemens, Ernst Werner
b. Lenthe, Germany, Dec. 13, 1816. d. Berlin, Dec. 6, 1892.

After fifteen years' service in the Prussian Army, he established works for carrying out many of the electrical inventions with which his fertile brain teemed.

Siemens, Sir William
b. Lenthe, Germany, April 4, 1823. d. London, Nov. 19, 1883.

The younger and more distinguished of the Siemens brothers came to England poor in pocket, but rich in scientific knowledge, and after many trials, established a great and successful business. Naturalised, he was the recipient of many distinctions for his inventions in metallurgy, and contributed works of great value to the scientific literature of the period. He and his brother generously helped the movement for the better education of aspirants to careers in science.

Simpson, Sir James Young
b. Bathgate, Scotland, June 7, 1811. d. Edinburgh, May 6, 1870.

The first man to introduce anæsthetics into British surgery was the son of a humble baker. He made many experiments before discovering the value of chloroform for his purpose, and fought a long fight against bigotry and prejudice before making his practice popular.

Smith, Adam
b. Kirkcaldy, June 5, 1723. d. Edinburgh, July 17, 1790.

After study at Glasgow and Oxford and filling professorial chairs at Edinburgh, he travelled as tutor to the Duke of Buccleuch, then settled down to studious retirement and the production of his famous works on political economy. Of these the "Wealth of Nations" remains still the economists' guide and source of inspiration.

Socrates
b. Athens, about 470 B.C. d. Athens, 399 B.C.

After following the calling of his father, that of a sculptor, Socrates gave himself up entirely to the study of philosophy, which he taught and expounded to such famous pupils as Plato, Xenophon, and Alcibiades. His life was one long campaign for truth and virtue. In his old age his enemies charged him with impiety and with corrupting the morals of the youth of Greece. He defended himself in a noble speech, but the verdict of partial judges going against him, he drank hemlock in his cell, surrounded by his disciples.

Sophocles
b. nr. Athens, 496 B.C. d. Athens, 405 B.C.

One of the three great tragic poets of ancient Greece, he defeated Æschylus, his elder by thirty years, in a tragic competition when twenty-eight years of age, and reigned supreme until Euripides was preferred, in 441. Although he discharged missions of State, his heart was always in his poetry, and he bequeathed to the world some of the masterpieces of human genius.

Speke, John Hanning
b. Ilminster, May 4, 1827. d. Bath, Sep. 15, 1864.

After service with the Indian Army, he explored the Equatorial lakes of Africa in company with Burton. While travelling alone he discovered the Victoria Nyanza, and in it the long-sought source of the Nile.

Spencer, Herbert
b. Derby, April 27, 1820. d. Dec. 8, 1903.

His father, a schoolmaster, intended him to follow the occupation of a railway-engineer, but Spencer threw up this calling for that of letters, and from early manhood began to develop the ideas which were eventually to issue in his System of Synthetic Philosophy. His writings have had a profound influence upon the thought of his own country, and an even greater effect upon foreign peoples, into whose languages they have been translated.

Spenser, Edmund
b. London, about 1552. d. London, Jan. 13, 1599.

Born of poor parents but good family, he proceeded from Merchant Taylors' School to Cambridge University. Winning the friendship of Sir Philip Sidney, to whom he dedicated his "Shepherd's Calendar," he was appointed, through Sidney's uncle, Lord Leicester, private secretary to Lord Grey de Wilton when the latter was sent to repress the rebellion in Ireland. Before crossing over, Spenser had begun his "Faerie Queen," and continued at his task in Ireland amid fierce fighting and plots culminating in the destruction of his own home there. Although he enjoyed great literary fame, his fortunes were of the most dismal character, and he died in London utterly destitute.

Spinoza, Benedict Baruch
b. Amsterdam, Nov. 24, 1632. d. The Hague, Feb. 21, 1677.

Excommunicated by the Jewish community, of which he was a member, he supported himself by grinding lenses, so that he might compose his works on philosophy and pantheism, which were destined to form the acknowledged basis of much of modern German philosophy.

Stanley, Sir Henry Morton
b. Denbigh, Wales, 1841. d. London, May 10, 1904.

His name was Rowlands, but on making his way from his poverty-stricken home to New Orleans, he adopted the name of an American Stanley, who befriended him. On growing up, he fought in the American Civil War, turned newspaper correspondent, and was sent on behalf of an American newspaper to the Abyssinian War. He so impressed his employer that later he was commissioned to head an expedition into Africa in search of Livingstone. This mission he accomplished, and afterwards made important explorations, and established for the King of the Belgians the Congo Free State. From another of his expeditions the British East Africa Company developed; while his final and not least notable journey through the Dark Continent was undertaken for the relief of Emin Pacha. Stanley married the skilful artist, Miss Dorothy Tennant, who survives him.

Steel, Sir Richard

b. Dublin, March 1672. d. nr. Carmarthen, Sep 1, 1720.

Soldier, member of Parliament, political pamphleteer, playwright, Steel is one of the few men whose newspaper writings have become immortal. His collaboration with Addison in the "Tatler" and "Spectator" was most happy, though the two friends ultimately quarrelled.

Stephenson, George

b. nr. Newcastle, June 9, 1781. d. nr. Chesterfield, Aug. 12, 1848.

First a farm-hand, next fireman at a colliery, he devoted his pocket-money as a youth to learning to read and write and sum. His first notable invention was a safety lamp for miners. Next came his first steam-engine, rendered successful by his later invention of the steam-blast. Upon becoming engineer for the first railway, he constructed the famous "Rocket" locomotive. He attained to great prosperity, and was employed on many important schemes during the race for railways which followed. His son, ROBERT STEPHENSON (b. Oct. 16, 1803. d. Oct. 12, 1859), won independent renown by the construction of many famous railway and other bridges.

Stevenson, Robert Louis Balfour

b. Edinburgh, Nov 13, 1850 d. Samoa, Dec. 3, 1894

Intended for the law, he never practised, but travelled by strange methods, and turned his experiences to account in some of the most charming writings in the language. He was equally distinguished as essayist and author of fiction, while much of his verse is admirable.

Strabo

b. Amasia, Pontus, about 63 B.C. d. about 21 A.D.

Little is known of the greatest geographer of antiquity, except from the record of his travels. These embraced visits to Greece and Italy, Egypt, up the Nile, Africa, and Asia Minor. His work "surpasses all the other geographical writings of antiquity, both in grandeur of plan and in the abundance and variety of its materials." Many of his estimates of the size and configuration of the world were hopelessly wrong, but the performance was very wonderful, his scanty resources considered.

Sullivan, Sir Arthur Seymour

b. London, May 13, 1842. d. London, Nov. 22, 1900.

He began his musical career as a choir-boy, studied at Leipzig, and at twenty years of age had made his name as a composer. Cantatas and oratorios, tuneful songs, and hymn-tunes, now famous wherever religious music is heard, followed. His most famous achievements, however, were the delightful comic operas which he produced in collaboration with Sir F. S. Gilbert.

Swedenborg, Emanuel

b. Stockholm, Jan. 29, 1688. d. London, March 29, 1772.

Distinguished as a scholar and military engineer, he wrote several works on natural philosophy before he began to dream dreams and see visions and to expound the Christian faith as it appeared to him. The Swedenborgian Church was established sixteen years after his death.

Swift, Jonathan

b. Dublin, Nov. 30, 1667. d. Dublin, Oct. 19, 1745.

The British Rabelais was first a power in the Whig Press, and afterwards one of the most trenchant writers on the other side. In addition to minor incumbencies held earlier, he was Dean of St. Patrick's, Dublin, for over thirty years. Much of his time was spent in London society prior to this appointment, but it was while in Ireland that he wrote most of his famous satires. His days were clouded by periods of madness, which condition, indeed, throughout the greater part of his life, he was frequently bordering. A strange fact is that "Gulliver's Travels," his supreme satire upon the cant and shams of the age, has become a children's classic.

Swinburne, Algernon Charles

b. London, April 5, 1837.

Son of an admiral, he quitted Oxford without a degree and travelled on the Continent, when he was the guest of Landor. His poems, which give him undisputed supremacy as a master of metrical invention, include some of the most exquisite lyrics in the language, while his prose writings are characterised by a vigour and charm of exceptional character. By common consent, he was the only poet worthy to succeed Tennyson as Poet Laureate.

Tacitus, Cornelius

b. Rome, about 52 A.D. d. Rome, about 117 A.D.

"The greatest man who has yet given himself to the recording of human affairs," as Froude describes him, was first famous as a legal orator. He married the daughter of Agricola, conqueror of Britain, and held offices under the State.

Tasman, Abel Janssen

b. Hoorn, Holland, about 1602 d. Batavia, Oct. 1659.

Despatched by Van Diemen, Governor of the Dutch East Indies, to seek "the great South Land," he discovered Tasmania (calling it Van Diemen's Land), New Zealand, part of the Friendly Islands, and ultimately the Bay of Carpentaria.

Tasso, Torquato

b. Sorrento, Italy, March 11, 1544. d. Rome, April 25, 1595.

Finding the pursuit of law and philosophy distasteful, he succeeded, by the production of a romantic poem, in persuading his father to let him follow his bent for letters. His noble epic, "Jerusalem Delivered," was followed by a mental breakdown. He imagined his rich and powerful friends to be his enemies, and had to undergo seven years' detention in a lunatic asylum. During his incarceration he wrote many noble verses and philosophical dialogues. Although released and able to continue his writings in freedom, he never wholly recovered, and died on being summoned to Rome to be crowned Poet Laureate.

Tennyson, Alfred Lord

b. Somersby, Lincs, Aug. 6, 1809 d. Aldworth, Sussex, Oct. 6, 1892.

One of a Lincolnshire rector's sons, of whom two besides himself were poets, Alfred Tennyson wrote verse as soon as he could write anything. He completed his education at Cambridge. The bulk of his loveliest lyrics were written before he passed his thirtieth year, and at forty-two he was promoted Poet Laureate, in succession to Wordsworth. In 1850 he published "In Memoriam," which, with the "Idylls of the King," constitute his noblest work. His poetical dramas, some of which were played in his own time, were of later date. His career ensured by a pension bestowed while he was yet young, his lot was happier far than that which usually falls to a great poet. He was created a baron when seventy-five.

Tesla, Nikola

b. Smiljan, Servia, 1857.

Educated with a view to devoting himself to mathematics and physics, he took up engineering, and has become one of the foremost inventors of electrical appliances.

Thackeray, William Makepeace

b. Calcutta, July 18, 1811. d. London, Dec. 24, 1863.

On his way home from India to England at St. Helena, he caught a glimpse of Napoleon. Educated at Charterhouse and Cambridge, he turned to art, but necessity compelled him to ply his pen for a livelihood. When he and Dickens were young, he asked to be allowed to illustrate "Pickwick," and Dickens refused his offer. Sustained success did not come to Thackeray until towards the end of "Vanity Fair," which was appearing serially. Then it turned completely in his favour. His domestic life was unhappy, his wife's mind giving way during the illness of one of their children.

Themistocles

b. about 525 B.C. d. about 459 B.C.

Famous as a general and statesman, he won for the Athenians the victory of Salamis.

Theocritus

b. Syracuse, 3rd Century B.C. d. Sicily (?), about 250 B.C.

He was the Greek poet of Nature and pastoral life, and his influence is to be traced in the work of many later classics.

Thucydides

b. Athens, about 471 B.C. d. about 401 B.C.

Warrior and scholar, he was condemned to death for his lack of success in the former capacity, but retired into exile and began his immortal work—the first of critical histories.

Titian

b. nr. Venice, about 1477. d. Venice, Aug. 27, 1576.

The chief of the Venetian school of painters and the greatest master of colour that the world has known, he worked for ninety years at his art, and died practically brush in hand.

Torricelli, Evangelista

b. Faenza, Italy, Oct. 15, 1608. d. Florence, Oct. 15, 1647.

His discoveries in relation to the gravity of the air resulted in the barometer, and his experiments with lenses gave us new and better telescopes and the microscope.

Tyndall, John

b. Leighlin Bridge, Ireland, Aug. 21, 1820. d. Haslemere, Surrey, Dec. 4, 1893.

Surveyor and engineer, he distinguished himself as a physicist and scientific author and lecturer.

Van Dyck, Sir Anthony

b. Antwerp, March 22, 1599. d. London, Dec. 9, 1641.

A pupil and asistant of Rubens, he specially distinguished himself by his portraits. His title was conferred by Charles I., by whom he was appointed painter to the English Court.

Velasquez, Diego Rodriquez de Silva y

b. Seville, June 6, 1599. d. Madrid, Aug. 6, 1660.

Velasquez was his mother's maiden name. His "Water Seller" made him famous, and he was taken to the Spanish Court, where he painted scores of works whose glories came as a revelation to later generations, but which in the meantime had remained little known in the gloomy royal galleries of Madrid.

Veronese, Paul

b. Verona, 1528. d. Venice, April 19, 1588.

His real surname was Caliari—Veronese refers to his birthplace. He was the last of the great Venetian painters.

Vespucci, Amerigo

b. Florence, March 9, 1451. d. Seville, Feb. 22, 1512.

The man whose Christian name the American Continent bears was sent by his employers to Spain, and fitted out one, if not two, of Columbus's expeditions. He claimed to have made four voyages to the New World, but there is no record of his actually having done so.

Virchow, Rudolf

b. Schivelbein, Germany, Oct. 13, 1821. d. Berlin, Sep. 5, 1902.

The son of a small shopkeeper, he became famous as a statesman, but infinitely more so as "the father of modern pathology." Among his many famous achievements was the establishing of what Lord Lister calls "the true and fertile doctrine that every morbid structure consists of cells which have been derived from pre-existing cells as a progeny." Of material results, the new Berlin, with its model sanitary system, water supply, and hospitals, is one of his monuments.

Virgil, Publius Virgilius Maro

b. Andes, Italy, Oct. 15, 70 B.C. d. Brundisium, Italy, Sep. 21, 19 B.C.

All his life an invalid, he devoted himself entirely to literary labour. He was the most painstaking of poets, and laboured incessantly at his task. His immortal Æneid he was unable to complete, and left instructions that, as the manuscript could not receive his finishing touches, it should be destroyed. Happily this order was disobeyed by the instructions of the Emperor Augustus.

Volta, Alessandro

b. Como, Italy, Feb. 18, 1745. d. Como, March 5, 1827.

Following up the investigations of Franklin and Galvani, he invented his Voltaic pile, the first instrument which artificially produced electricity, causing that science, with chemistry, to develop with astounding speed and certainty.

Voltaire

b. Paris, Nov. 21, 1694. d. Paris, May 30, 1778.

Born François de Marie Arouet, he assumed the style of Voltaire. His wit gained him admittance to the French Court, but his sharp tongue twice brought him into disgrace. He came to England and consorted with the leading literary spirits of the age, then returned to Paris. Here he got into hot water again, and went ultimately to the Court of Frederick the Great, from whom he parted on unfriendly terms three years later. He settled in Geneva until shortly before his death, when the excitement of a visit to Paris proved too much for him. His literary output was prodigious, his correspondence immense, his influence immeasurable. He had no reverence for good, but he h... an unfailing eye for evil, and denounced unsparingly wherever he found it. He helped free Europe of the oppressive feudal bonds wh... bound it.

Wagner, Richard

b. Leipzig, May 22, 1813. d. Venice, Feb. 13, 1883.

He was a brilliant scholar as a boy, and before he was fourteen had translated a great part of Homer and written a tragedy. Weber and Beethoven inspired him to musical composition, but, in spite of his literary and musical gifts, he had a desperate struggle with fortune. It took him fifteen years to get a hearing for his "Faust" overture, and opera after opera was coldly received. He was often in great distress until Ludwig II. invited him to the Bavarian Court. A special theatre for his works was built at Bayreuth, and gradually his compositions grew in fame. He lived to see the triumph of his genius.

Wallace, Alfred Russel

b. Usk, Mon., Jan. 8, 1822.

Educated as a surveyor and architect, he gave his attention to natural history, explored, and, simultaneously with Darwin, formulated the theory of natural selection.

Walton, Isaac

b. Stafford, Aug. 9, 1593. d. Winchester, Dec. 15, 1683.

At one time a linendraper in London, he settled down to country life, and wrote his famous "Compleat Angler," which, with his classical volume of biographies, ranks as one of our most precious literary treasures.

Washington, George

b. Bridges Creek, Virginia, Feb. 22, 1732. d. Mount Vernon, Dec. 14, 1799.

During the war in America between England and France he fought under the British flag, but in the Rebellion took arms for his native land. He handled his forces with supreme ability, and though it was an army ill-disciplined, ill-fed, and ill-equipped, he led it in the end to complete victory over the English troops. His compatriots would now have made him King, but he was as modest as he was noble, and though he accepted the position as head of the nation, it was only as the elected President of the United States.

Watt, James

b. Greenock, Jan. 19, 1736. d. nr. Birmingham, Aug. 19, 1819.

From the shop of an instrument-maker in London he graduated as mechanic and inventor. To his credit stands the practical steam-engine and steam condenser. With Boulton he established the famous works at Birmingham.

Wellington, Arthur Wellesley, Duke of

b. Dublin, April 29, 1769. d. Walmer Castle, Sep. 14, 1852.

He was the dull boy of the family, yet in his first military action showed genius. He had not much faith in a military career, and unsuccessfully sought civil employment. His chance came in India, where, in the course of eight years, he won great distinction as a leader of men and as an administrator. His supreme honours were not realised, however, until he took command in the Peninsula and drove the French out of Spain and captured Toulouse. For this feat he received £400,000 from Parliament, with honours in abundance from half the nations of Europe. Napoleon's escape from Elba and the subsequent battle of Waterloo took Wellington into the battle-field for the last time, and brought him further distinctions and rewards. Entering political life, he became Prime Minister, but was not in sympathy with popular aspirations, and on one anniversary of Waterloo was besieged by a mob in his own house.

Wells, Henry George

b. Bromley, Kent, Sep. 21, 1866.

The son of a professional cricketer, he was apprenticed to a linendraper, but by perseverance emancipated himself, and became schoolmaster's assistant. A course of study at the Royal College of Science brought him under the influence of Huxley, by whose aid he was able to take first-class honours with his B.Sc. degree. A career as a scientist was prohibited by a breakdown in health. He found his true vocation, however, in letters, in which he was destined to play an important part as a gifted and original writer upon social reform. He is equally impressed by the stupidity of the race and by its immense possibilities.

Wheatstone, Sir Charles

b. Gloucester, Feb. 1802. d. Paris, Oct. 19, 1875.

With W. F. Cooke he invented the instrument out of which has grown the electric telegraph system of the United Kingdom.

Wesley, John

b. Epworth, Lincs, June 17 (o. s.), 1703. d. London, March 2, 1791.

"The Ignatius Loyola of the English Church" distinguished himself as a scholar at Oxford University, and had been curate to his father and a Church missionary in Georgia before entering upon the work in Britain which gave the world a new and mighty religious denomination—the Wesleyan Methodists. No man ever lived a fuller life. Wesley's itineraries of over 250,000 miles, the dangers he experienced, the vast literary labours he accomplished, the wonderful organisation he built up, constitute one of the great romances of modern biography. He distributed vast sums in charity, and, with his brother Charles, wrote a number of hymns still in general use.

White, Gilbert

b. Selborne, Hants, July 18, 1720. d. Selborne, June 26, 1793

"White, of Selborne," was a fellow of Oriel College, Oxford, but became curate of his native Selborne. There he indulged his love of natural history and antiquarian interest, and wrote his immortal work on his observations. The book, a classic beyond price, has done more than any other work in the language to inculcate a love and knowledge of nature.

Whitefield, George

b. Gloucester, Dec. 16, 1714. d. Boston, Sep. 30, 1770.

While at Oxford he was caught by the wave of religious enthusiasm which the Wesleys had started, and accompanied John Wesley on his mission to Georgia. Upon his return he was admitted to Orders, but his burning eloquence and liberal views caused the pulpits of the Church to be closed against him. Thereafter his life was devoted to mission work, in which he had marvellous success. Although there were points of doctrine upon which he and Wesley differed, Whitefield was a very potent factor in the foundation of Methodism. He made seven expeditions on mission work to America, and died there.

Whitney, Eli

b. Westborough, Mass., Dec. 8, 1765. d. New Haven, Conn., Jan. 8, 1825.

In days when the cotton had to be slowly separated from the seed by hand, he gave years of his life to the invention of the cotton-gin. At last he succeeded, but unscrupulous rivals broke into his premises, stole his invention, and made copies of it before he could patent it. The invention, which added hundreds of millions of pounds to the wealth of America, brought him a £10,000 grant from the Government, which su with all his profits, was swallowed up in law su , undertaken to protect his interests. He afterwards realised a fortune as a manufacturer of firearms.

Wilberforce, William

b. Hull, Aug. 24, 1759. d. London, July 29, 1833.

Closely associated with Pitt, though an independent politician, he began as a young man his campaign for the abolition of the slave trade and for the emancipation of its victims. By many of his contemporaries he was deemed a fanatic, but his devotion to the righteous cause he had made his own was crowned with victory after a nineteen years' struggle. The Emancipation Bill, however, was not passed until a month after his death.

Wilkie, Sir David

b. Cults, Fifeshire, Nov. 18, 1785. d. off Gibraltar, June 1, 1841.

He painted before he could write, and though scantily furnished with means, made himself one of the most famous genre painters of his age.

William I., The Conqueror

b. Falaise, Normandy, 1027 or 1028. d. nr. Rouen, Sep. 9, 1087.

His father was Robert III., Duke of Normandy, his mother a tanner's daughter. Although not lawfully entitled to the crown of Normandy, the nobles made him successor to his father. Edward the Confessor, his cousin, promised him the English Crown. Harold pledged himself to help William to gain it; but, at the death of Edward, was himself crowned. William defeated him at Hastings, and was crowned on December 25, 1066. The Conqueror was a born statesman and warrior. He ruthlessly repressed rebellion, he committed many cruel acts of tyranny, but he made England and the English nation, and historians rank him with Alexander the Great, Constantine, and Charlemagne.

William III.

b. The Hague, Nov. 4, 1650. d. London, March 8, 1702.

The son of William II., Stadtholder of the United Netherlands, he was the grandson, through his mother, of Charles I., and married the elder daughter of James II. When the misconduct of the latter caused the English people to turn him from the Throne, William was brought over and crowned King. He carried out many striking reforms, among which was the making absolute of the will of the people, through Parliament, the establishment of our modern system of national finance, control of the Army by Parliament, and liberty of the Press. This he accomplished in the face of many difficulties, and in spite of many attempts upon his life by Stuart adherents.

Wolsey, Thomas, Cardinal

b. Ipswich, 1471. d. Leicester, Nov. 29, 1530.

His father, a grazier and wool merchant, had him educated at Oxford University, and at thirty-five Wolsey had become a royal chaplain. During the next five years he became indispensable to Henry VIII., who found him a powerful ally in peace and war, and made him Lord Chancellor. Thwarted in his designs upon the Papacy, Wolsey aided Henry in the dissolution of the monasteries, but fell from favour when he failed to secure the King's divorce from Catherine of Arragon, and was deprived of his offices. Restored to the Archbishopric of York, he was still obnoxious to lords and commons for his unjust taxation of the nation, and the wanton insolence with which he had behaved. He was now called upon to take his trial for high treason, but died on the way to London. Although a man of many and grave faults, he did much for education, and history has shown that his own ambitions were coincident with the interest of his country as he conceived it.

Wordsworth, William

b. Cockermouth, April 7, 1770. d. Rydal Mount, April 23, 1850.

After completing his education at Cambridge, he travelled on the Continent, and became imbued with Republican sentiments, which afterwards underwent considerable modification. His friendship with Coleridge determined his career as a poet, and a legacy of £900 from a friend made that career possible. His means were further enhanced by an office as distributor of stamps, while with the Poet Laureateship came, of course, the customary pension. Although he travelled now and again to the Continent and to Scotland, his life was passed almost wholly amid the glories of the Lake Country. Wordsworth's influence upon the poetry of the country was second to none.

Wren, Sir Christopher

b. East Knoyle, Wilts, Oct. 20, 1632. d. Hampton Court, Feb. 25, 1723.

The greatest of English architects was a singularly gifted man, and was first notable in helping to perfect the barometer and as a professor of astronomy. The Great Fire of London gave him his opportunity as an architect. He rebuilt St. Paul's Cathedral, and fifty of our noblest churches, and designed a London of noble thoroughfares and magnificent quays Unfortunately there was not available money enough to carry out the scheme, but many buildings in and about London bear witness to his genius.

Wycliffe, John

b. nr. Richmond, Yorks, about 1324. d. Lutterworth, L'trshire, Dec. 31, 1384.

A distinguished scholar of Oxford, where he became Master of Balliol College, he discharged ecclesiastical offices with those of ambassador. Opposed to the corrupt and scandalous system in the Roman Catholic Church of the time, he boldly addressed the people in pamphlets written in English. Previously all writings for public perusal had been in Latin. He also, with assistance, translated the Bible into English, and to his life's end fearlessly carried on his campaign for the worship of God unfettered by enforced confessions to priests, penances, and indulgences.

Xavier, St. Francis

b. Xavier, Navarre, April 7, 1506. d. San-Chian, Canton, Dec. 22, 1552.

"The Apostle of the Indies" was associated with Loyola in establishing the Society of Jesus, and laboured with phenomenal success as a missioner in the Portuguese colonies in the East.

Xenophon

b. Athens, about 430 B.C. d. Corinth, 354 B.C.

A disciple of Socrates, whose memory he defended in a masterly work, he took part in the expedition of Cyrus the Younger against King Artaxerxes Mnemon. After the death of Cyrus, Xenophon succeeded to the command of the 10,000 Greeks, and led them on their celebrated retreat, through 1,500 miles of hostile country, to the sea. As a historian and essayist Xenophon occupies a foremost place.

Ximenes, Cardinal

b. Torrelaguna, Spain, 1436 d. Roa, Spain, Nov. 8, 1517.

Although as Grand Inquisitor he put to death over 2,500 persons in the sacred name of religion, Ximenes was one of the noblest spirits of his age. His virtues made him a Cardinal and Regent of Spain. He governed at eighty years of age with astounding energy and success, broke the feudal spirit of the lawless nobles, restored lands wrested from the Crown, reformed finances, and created educational institutions on a lavish scale. During the time of his might and influence he observed the austerities of the cloister, always wearing under his robes the coarse frock of the Franciscan monk.

Zola, Emile

b. Paris, April 2, 1840. d. Paris, Sep. 22, 1902.

His father, a poor engineer, bequeathed to him nothing but energy and imagination, and Zola's early years were a period of terrible poverty. He succeeded at last in obtaining a situation as clerk, which enabled him to live until he had cut a way with his pen into public attention as a new force in literature. His novels are books of tremendous power, but many of them picture with relentless detail the most detestable features in the worst of lives; they idealise bestiality. He played a heroic part in the rehabilitation of Captain Dreyfus.